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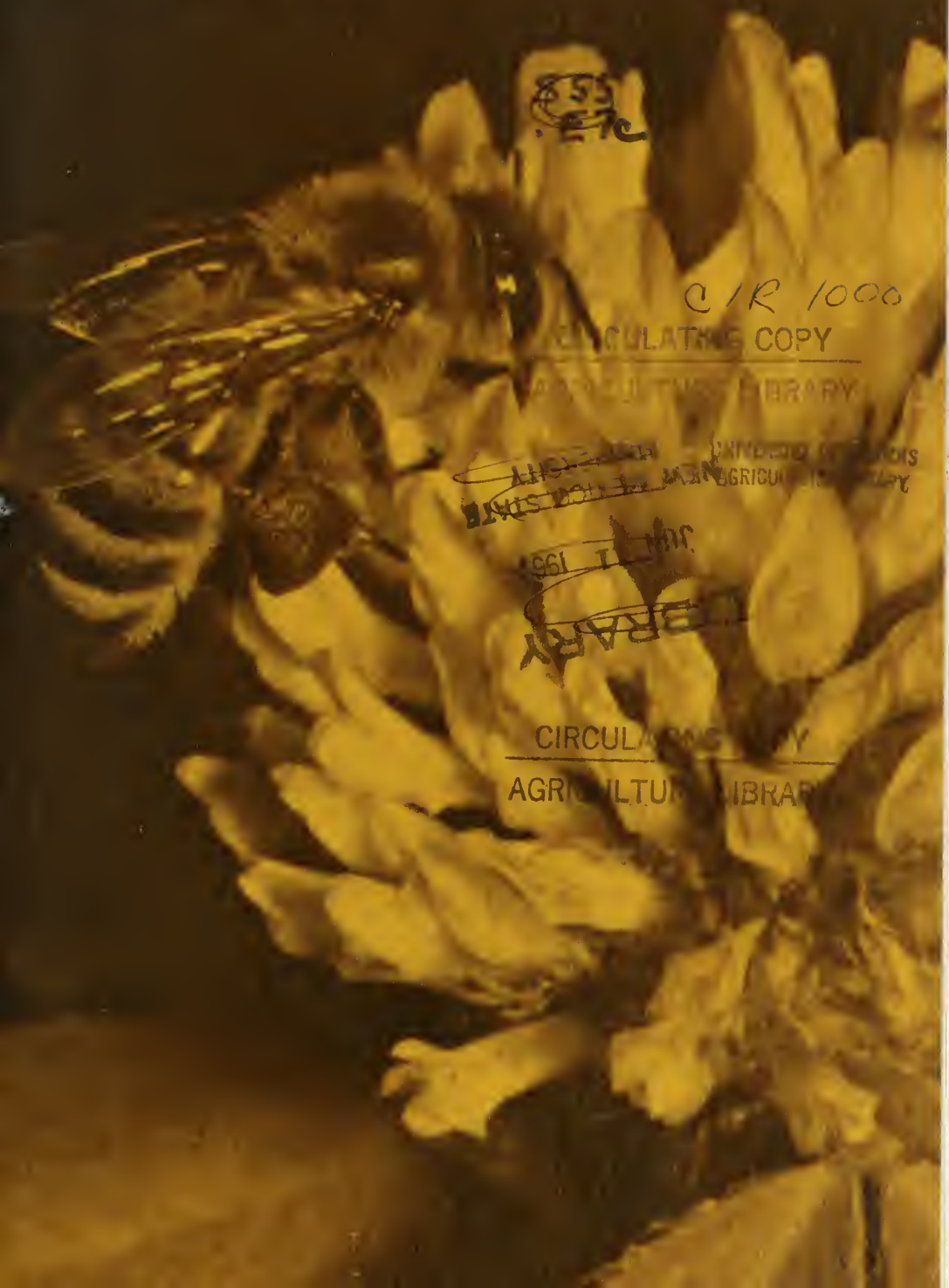
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ALBERT R. JAYCOX



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BEEKEEPING IN ILLINOIS

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HONEY BEES have a long association with man and are often regarded as domesticated animals. But they are able to live either with or without man's help and specialized hives. Essentially, man must adapt to bees more than bees must adapt to man. No other animal species serves man in as many ways as do honey bees. They are kept for a hobby and for full-time business, they are used as research animals by scientists, and they are valued as pollinators of fruit, seed, and vegetable crops. Because of their social way of life and their adaptability, honey bees survive in most areas of the world. However, to manage them properly for the greatest return, you must understand their behavior and analyze their needs throughout the year.

Beekeeping in Illinois began with the early settlers and farmers who kept bees as a source of honey for home use and for sale. Bees first thrived on the native flowers and trees, and later also on apple trees and large acreages of clover pastures that were planted as farm crops. By 1930 the acreage of sweetclover in Illinois had risen to 850,000 acres and provided large honey crops for an estimated 275,000 colonies (hives) of bees. If the estimates were correct, only California had more bees at that time. Since then the number of colonies has declined steadily to the present number of about 90,000.

Illinois residents have made valuable contributions to beekeeping in the United States. Prominent among them are the members of the Dadant family of Hamilton, Illinois (Fig. 1). Charles Dadant emigrated from France in 1863 and began keeping bees and making comb foundation. By 1867 he was contributing articles to American and foreign journals and soon thereafter began selling queen bees. His son, C. P. Dadant, continued the business and became editor of the *American Bee Journal* in 1912. This magazine, published since 1866, has served as a sounding board for amateur and commercial beekeepers, and has given sound counsel and information for four generations. The present company, Dadant & Sons, Inc., publishes the *Journal* and specializes in beeswax and its products as well as in beekeeping equipment. Dadant's hybrid-queen breeding program is the only one of its kind in the world.

The University of Illinois first offered beekeeping instruction about 1917. Professor Vern G. Milum taught two popular courses from 1925 until his retirement in 1962.



The old Dadant home and apiary, north of Hamilton, Illinois, in the early 1900's. (Fig. 1)

Illinois beekeeping has changed rapidly in the 20th century. Commercial honey production now requires more extensive operations than in the early days because nectar sources are more widely scattered. Increased urbanization has reduced the number of bees kept in and around cities. However, small numbers of colonies do well in cities and towns because of the diversity of flowering plants within the flight range of the bees. The increasing acreages of vegetable and fruit crops requiring pollination in Illinois are creating a demand for more pollination service. The commercial beekeeper who provides such a service by moving his hives to the vicinity of the crop to be pollinated helps to increase crop yields while reducing his dependence upon honey production as his only source of income.

Learning to handle and manage bees is fun. It also offers simple rewards such as tasting the first crop of honey and watching a queen bee emerge from her cell. Consider joining the local and state beekeeping organizations. Sharing your experiences can increase your pleasure from bees. Young beekeepers can gain by joining 4-H or FFA and participating in beekeeping projects sponsored by these organizations.

BEES: THE INDIVIDUAL AND THE COLONY

The first step in studying bees is to learn as much as possible about their biology. This information about their life and needs is required to manage and maintain the colonies properly. It is even more important when you must diagnose an ailing colony that may have lost its queen or become infected with disease.

Honey Bee Castes

There are three castes,¹ or groups of individuals, in honey bee communities. These are the workers, the drones, and the queens. All are important to a colony and to the survival of the species.

The castes are easy to recognize after a little practice. The three types of castes are shown in Figure 2. The two kinds of females, queen and worker, are more similar before the queen mates and begins to lay eggs than they are after that time. The overall body size of the queen, and particularly her thorax, is noticeably larger even at that time, but her abdomen is short and pointed, much like a worker's. As she begins to lay, the queen's abdomen becomes greatly elongated, so much so that her wings look short. They cover only about two-thirds of her abdomen. In contrast, the wings of both workers and drones reach the tip of the abdomen when folded. Drones have large, stout bodies with blunt abdomens. There is usually a conspicuous brush of hairs at the end of the abdomen. The drone's compound eyes are easily distinguished from those of the other bees in the hive because they meet on the top of his head. Queens and workers have areas of hair and their simple eyes, the ocelli, between their compound eyes.

The Workers

The worker bees (Fig. 3) are the largest group of bees in the hive — up to 60,000 in midsummer. They develop in the smallest cells in the comb of the colony from fertilized eggs laid by a queen. They are imperfect females and under normal hive conditions they do not lay eggs. The young, grub- or worm-like larvae receive large quantities of food

¹ All specialized terms are defined in the Glossary.



The three honey bee castes. The worker bee is at top left, the drone is below the worker, and a marked queen is the large bee at right. (Fig. 2)



A worker bee.

(Fig. 3)

that surround and support them for the first few days after they hatch from the egg. As the larvae grow, they consume all the excess food. The nurse bees then feed them small quantities of food at frequent intervals. About 5 days after hatching, the larva is sealed in its cell where it spins a partial cocoon and begins the body changes, or metamorphosis, that produce the pupa and finally the adult worker bee. The cell capping on worker cells is flat or only slightly convex. There are about 55 worker cells to the square inch, including both sides of the comb.

About 21 days after the egg was laid, an adult bee emerges from the comb by chewing a hole in the capping. She is soft and downy, and is not yet capable of making wax, stinging, or flying. She will spend more than half her life doing hive duties in a rather flexible sequence that is governed by the colony's needs. Usually this begins with cell cleaning and feeding and caring for the brood (the immature stages of bees) (Fig. 4). Other typical duties include comb building, removing debris, and guarding the entrance (Fig. 5). Although we think of bees as being very industrious, the workers spend many hours patrolling the hive and sitting idle on combs. The patrolling probably serves to inform bees of the needs of the colony and also produces heat to maintain the warmth of the brood nest where the young bees are reared.

Young workers begin to fly from the hive when they are 15 to 20 days old. At first they take short flights in front of the colony, often



A young worker bee feeding a larva.

(Fig. 4)



Worker bees on guard at the hive entrance.

(Fig. 5)

on warm afternoons. These flights acquaint the bee with the appearance of the hive and its immediate vicinity. The term "play flights" has been given to this activity because the bees bob and weave in the air while facing the hive.

Workers forage first for either pollen or nectar. They may change from one to the other but usually collect pollen first and nectar later. The nectar collectors may also collect water when the colony needs it, and a few bees collect plant resins called propolis or bee glue.

Workers live 4 to 6 weeks during the active season. Those reared in the fall may live as long as 6 months so that a new generation can be developed before they die in the spring. The colony uses large quantities of honey and pollen as food but the bees usually store more honey than the colony needs. Only this surplus production should be removed by the beekeeper (see page 55). The young worker bee needs pollen to develop the glands that are used to make the secretions fed to developing larvae and to the queen. Adult bees can survive without pollen, but they are soon unable to rear young bees. Wax is produced by glands on the underside of the abdomen of house bees. It is secreted only when the colony is obtaining considerable quantities of nectar or is being fed sugar or honey by the beekeeper.

The Drones

The male bees, or drones, appear in the colony in late spring (Fig. 6). No certain number is produced and colonies may have only a few hundred or as many as several thousand. They help to produce

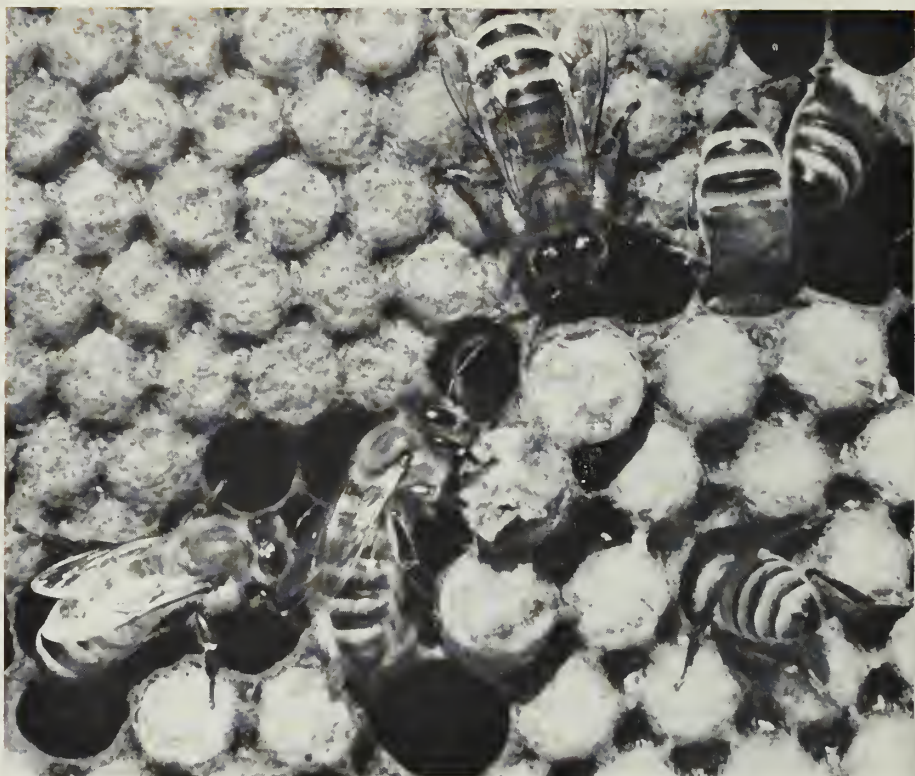


The drone. Note the blunt abdomen and the eyes that meet on the top of the head. (Fig. 6)

heat in the colony and may be of value by affecting the "morale" of the colony or in other ways that are still not known. However, since they consume food and take up space, their numbers should be kept at a minimum by using full sheets of comb foundation and maintaining combs with few drone cells.

The drones are produced from unfertilized eggs usually laid by a queen but occasionally by workers whose ovaries have developed (laying workers). A normal queen lays drone eggs in cells that are larger than worker cells. When sealed, the cells have distinct, rounded cap-pings (Fig. 7). Both laying workers and queens unable to lay fertilized eggs produce drones in worker-sized cells. Those that survive are normal, small drones, but many of them do not grow to maturity in the smaller cells. Drones require 24 days to develop from egg to adult.

Another type of drone is produced in some honey bee colonies. However, they are never seen as adults because the worker bees remove them from the comb a day or two after the larvae hatch. These drone larvae hatch from fertilized eggs that have a matching pair of hereditary factors called sex alleles. The eggs are laid in worker-sized cells by a queen that mated with one or more drones having a sex allele the same as one of hers. Eggs with a single allele are unfertilized and usually laid by the queen in large cells of the comb where they produce normal drones. Fertilized eggs with two different sex alleles produce normal worker bees.



Worker bees on sealed brood. The worker cells are at the top left and the drone cells at the bottom right. (Fig. 7)

The production and loss of these drones, called diploid drones, is detrimental to a colony because as many as half of the fertilized eggs do not produce worker bees. The colony fails to develop the large population needed for honey production. A spotty brood pattern when no disease is present may indicate this problem and the colony should be requeened.

Young drones are fed by workers for the first few days of their lives. After that time they help themselves to the stored honey and fly in search of queens on warm afternoons. Drones are attracted to certain small areas where they congregate and patrol while flying 30 to 50 feet above the ground. It is here that they usually meet and mate with queen bees.

When flowers cease to provide nectar for the colony, either in the fall or, more rarely, at any time of the year, the workers no longer tolerate the drones. Workers remove developing drones from the comb and begin to harass the adults, the oldest ones first. The drones are rarely stung but they are pushed and pulled so much that they have

difficulty eating. Ultimately, all the drones in a queenright colony are driven from the hive and die. The Italian race tolerates them longer than the Caucasians, and queenless colonies allow them to stay for an indefinite period.

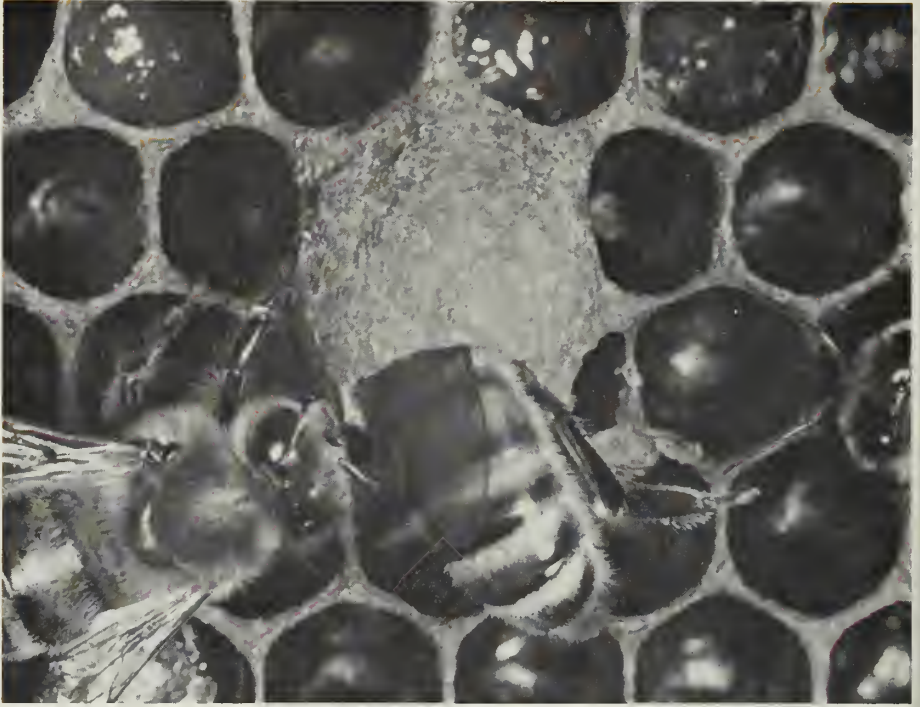
The Queen

The queen (Fig. 8) is responsible for all the qualities of her colony. The fathers of the workers are not present. The workers share the queen's motherly duties by caring for the young, but her genetic or hereditary makeup, and that of the drones she has mated with, determines the size and temper of the colony, the color of the workers and drones, disease resistance, honey-producing ability, and all the other characteristics of the colony.

Queens develop from fertilized eggs or from young female larvae not over 3 days old. In a colony with a good, young queen, the eggs destined to be new queens are laid in special cells, or cell cups, that hang vertically on the comb (Fig. 9). Worker and drone cells are on a horizontal plane. The young queen larva develops much like a worker but does so more quickly, in only 16 days, and more completely. She receives glandular secretions, called royal jelly, in excess quantity throughout her life. Queen larvae float in a bed of food. This greater quantity of food together with other differences in quality and content,



Honey bee queen, marked on the thorax. (Fig. 8)



Queen cell cup being prepared by worker bees.

(Fig. 9)

make the resulting queen a perfect female with a complete reproductive system.

When she emerges from her cell, the young queen is practically ignored by the workers. Very quickly, however, they are attracted to her and begin to feed and groom her. They even bite and chase her within the hive during the first few days. After about a week the queen is agile and physically ready for her mating flight. She leaves by herself, usually between noon and 4 p.m., and probably flies a considerable distance from the hive. It seems likely that queens visit drone-congregation areas because they mate with many drones in a short period. The average queen makes more than one mating flight and mates with as many as 10 different drones. This system of mating reduces inbreeding and thereby increases the efficiency of the colony.

The mated queen begins to lay a few days after completion of her flights. Her egg production increases rapidly to as many as 2,000 eggs per day. This high output, equal to the queen's own weight, is made possible by the high-protein diet of glandular secretions provided in large quantity by the worker attendants.

If a queen is removed or killed in a colony, the workers can produce a replacement if they have worker eggs or larvae not more than 3 days

old. They usually select several larvae whose cells are then modified into queen cells. The development of such queens is the same as the development of those that begin life in a queen cell.

Queens lay eggs in greatest numbers in the spring and early summer. They gradually cease to lay in the fall and do not begin again until January or February. Winter brood rearing is normal and takes place in most colonies that have adequate stores of honey and pollen and a good population of worker bees.

Queens may live as long as 5 years but are most productive during the first 2 years. A common cause of failure is inadequate mating that results in the production of too many drones when the queen is unable to fertilize the eggs she lays in worker cells. At that time the colony usually tries to replace her by a process called supersedure. An old, failing queen and her young daughter may continue to live and lay eggs in the same colony for a considerable period.

Length of Development

The three honey bee castes undergo the same type of development, known as complete metamorphosis. Each one takes a different length of time to develop as follows:

	Queen	Worker	Drone
	<i>Day</i>		
Egg is laid.....	0	0	0
Egg hatches	3rd	3rd	3rd
Cell is capped.....	8th	8th	10th
Adult emerges.....	16th	21st	24th

The Races of Bees

Throughout the world there are many races of bees that have developed slightly different body characteristics, biology, and behavior. In the United States two races of bees are most common — the Italian and the Caucasian. The Italian bees have yellow or brown bodies with varying numbers of dark bands toward the end of their abdomens. They tend to raise young bees early and late in the year and need more honey for maintenance than do the dark races. The Caucasian bees are black with gray bands of hair. They conserve their honey somewhat better and use more propolis than the Italian bees. Both races are usually gentle and the bees are quiet on the combs. Carniolan bees are a dark race with characteristics somewhat similar to the Caucasians.

The honey bees available in the United States are the result of crossing and selection of bees from many different races in addition to those mentioned above. Beekeepers should try queens from different queen breeders to learn more about the behavior and honey production

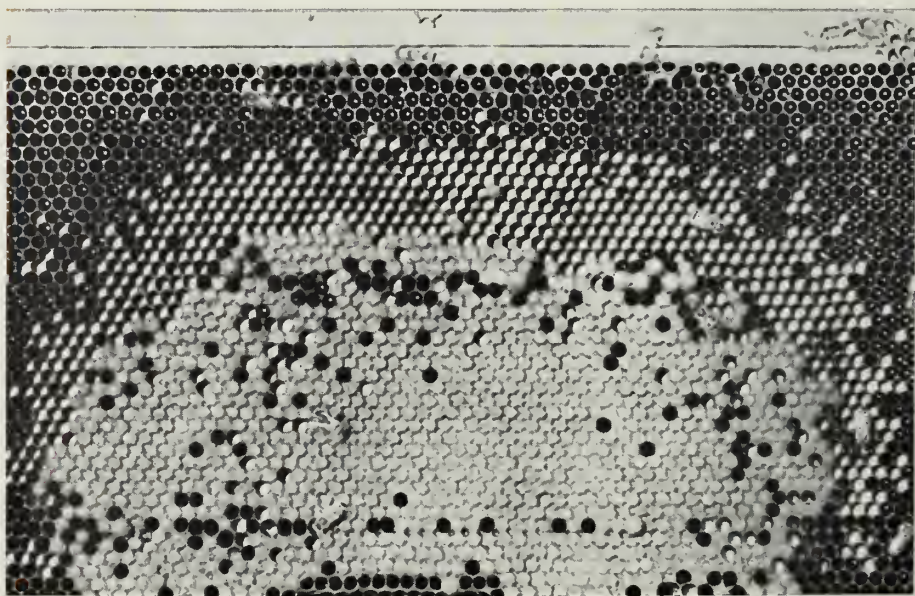
of different strains of the same race. Most strains are gentle when handled under the proper conditions. If you have bees that are not gentle, requeen them immediately with a queen from a gentler strain. There is no relation between temper and honey production.

Characteristics and Activities of the Colony

Honey bee colonies are often regarded as a single organism because they undergo changes as a group that compare with the changes and development of an individual. To understand and manage honey bees you must be familiar with the development of the colony and the seasonal changes in it.

The brood nest, where the queen lays eggs and young bees are reared, is the heart of the colony. It may be a small circle of cells on one side of a comb or as large as 20 or more full combs (frames). It is usually oval or circular so that the bees may surround it readily in cool weather. The entire area of developing bees, but not the rest of the hive, is kept at a temperature of about 95° F. The worker bees produce heat to warm the brood nest to this temperature. They ventilate and evaporate water or nectar to cool it to 95° in hot weather.

The bees store pollen, their protein food, in the cells immediately surrounding the brood (Fig. 10). In this location it is near at hand to



A comb with sealed brood in the center surrounded by a ring of light-colored pollen. Outer cells of the comb contain honey in open cells. (Fig. 10)

feed to developing larvae and to be eaten by newly emerged adult bees. The nectar and honey are stored beyond this band, or shell, of pollen.

In the fall, the brood nest and the majority of the bees are in the lower combs of the hive. The honey for winter food is above them and there must be pollen stored within the cluster area for winter use. During the winter the bees in a hive of adequate size (at least two deep hive bodies) move upward as they gradually eat the stored honey. In early spring the brood nest is most often in the top part of the hive with empty combs beneath it. If nothing is done to change this arrangement, the bees will slowly occupy the lower combs, and the queen will expand her laying to all areas of the hive. However, the direction of natural expansion is upward so the beekeeper usually rearranges the hive, as explained on page 45.

Theoretically, one set of 10 deep combs is sufficient space for a prolific queen. In practice, 18 or 20 combs used in two 10-frame hive bodies provide more suitable conditions for a large brood nest, perhaps because it can be more nearly spherical in shape. The colonies need additional room for their rapidly increasing number of adult bees by late April or early May in central Illinois. The nectar and pollen gathered from fruit blooms and dandelions may contribute to the crowding. The bees continue to store pollen near the brood nest and honey in the combs above it throughout the honey season. Without sufficient comb space, the workers gradually will fill the cells of the brood nest with honey. This is highly desirable in the late summer to provide food for winter, but it is harmful earlier in the season when the greatest possible number of cells is needed for rearing young bees. The crowded brood nest restricts the queen's laying.

The success and adaptability of the honey bee colony is the result of several means of communication, both simple and complex. The simpler system of communication is based upon the exchange of food (Fig. 11), and on odors within the hive. The queen's glands secrete attractive substances and odors that are removed from her body and shared by the workers of the colony. The materials keep the colony together and prevent the workers from laying eggs and building queen cells. If there is an insufficient supply, or if it is not distributed evenly in a crowded colony, the bees construct queen cells to produce a new queen. Another system is used to alert and alarm the colony. Disturbed and injured bees secrete a volatile material known as isopentyl acetate that smells like banana oil. It attracts and excites bees and prepares them to defend the colony by stinging the cause of the disturbance.

The more complex communication system of the colony consists of elaborate movements made on the combs by foraging bees. They are



Worker bees exchanging food on a comb containing honey. The two bees in the center are responding to smoke by eating honey from open cells.

(Fig. 11)

usually called dances or the “language” of the bee because the movements and sounds produced give other bees information about the odor, distance, direction, and quality of a source of nectar. Field bees learn the daily movement of the sun in the sky and apparently measure distances by the energy they use in reaching the source of food. These dances and the responses of the house bees and inexperienced forager bees make it possible for a colony to quickly find and collect the best sources of nectar. Field bees actually recruit others to come to the same flowers for food. A similar system operates for pollen sources.

The colony selects a new home when it swarms by using a system of communication similar to the one used for food. In this case the field bees evaluate the hollow tree, cave, or hole in a house, and induce other bees to come and inspect it. The site agreed upon as best is selected for the new home of the swarm.

BEEKEEPING EQUIPMENT

Honey bees have been kept by man in a wide variety of hives. In the early days of the United States the most common hive was the section of a hollow tree, called a "gum" or "log gum," with a slab of wood to cover the top of it. In Europe the straw skep hive was common and one model used in Greece had movable combs. In most other early hives it was not possible to remove or exchange combs easily because the bees glued everything firmly together and their combs were not surrounded by wooden frames. In 1851, L. L. Langstroth designed an improved hive that utilized a principle discovered earlier and now called the "bee space." He made a hive in which the frames hung within a box so that they were surrounded on all sides by a space of $\frac{1}{4}$ - to $\frac{3}{8}$ -inch. Bees leave such a space open but smaller spaces are usually filled with propolis. In larger spaces bees build extra comb. Langstroth's design is now used in all modern beekeeping equipment and, although the dimensions and some details have been changed, the hive is still called the Langstroth hive.

Bee hives have often been designed and built without regard for the needs and habits of the honey bee colony. Probably the best design for a colony was the large hive developed by Charles Dadant. It provided a large, deep brood chamber with plenty of room in which the queen could lay, and shallower supers for honey storage. However, the price and promotion of smaller hives offered for sale during the period from about 1885 to 1900 made them more popular. These small hives have since been blamed for the reduction in the numbers of farm apiaries because farmers removed too much honey from them, allowing colonies to starve during the winter. The 10-frame Langstroth-style hive has gradually become the standard hive used in the United States. It is essentially a compromise between the needs of the bees and a size one man can handle and move. As commercial beekeeping becomes more mechanized, there is less reason to limit the hive size and shape just for convenience in lifting and moving hives. But the amateur beekeeper will continue to need a hive whose parts he can lift, and the 10-frame Langstroth with shallow supers fills this need.

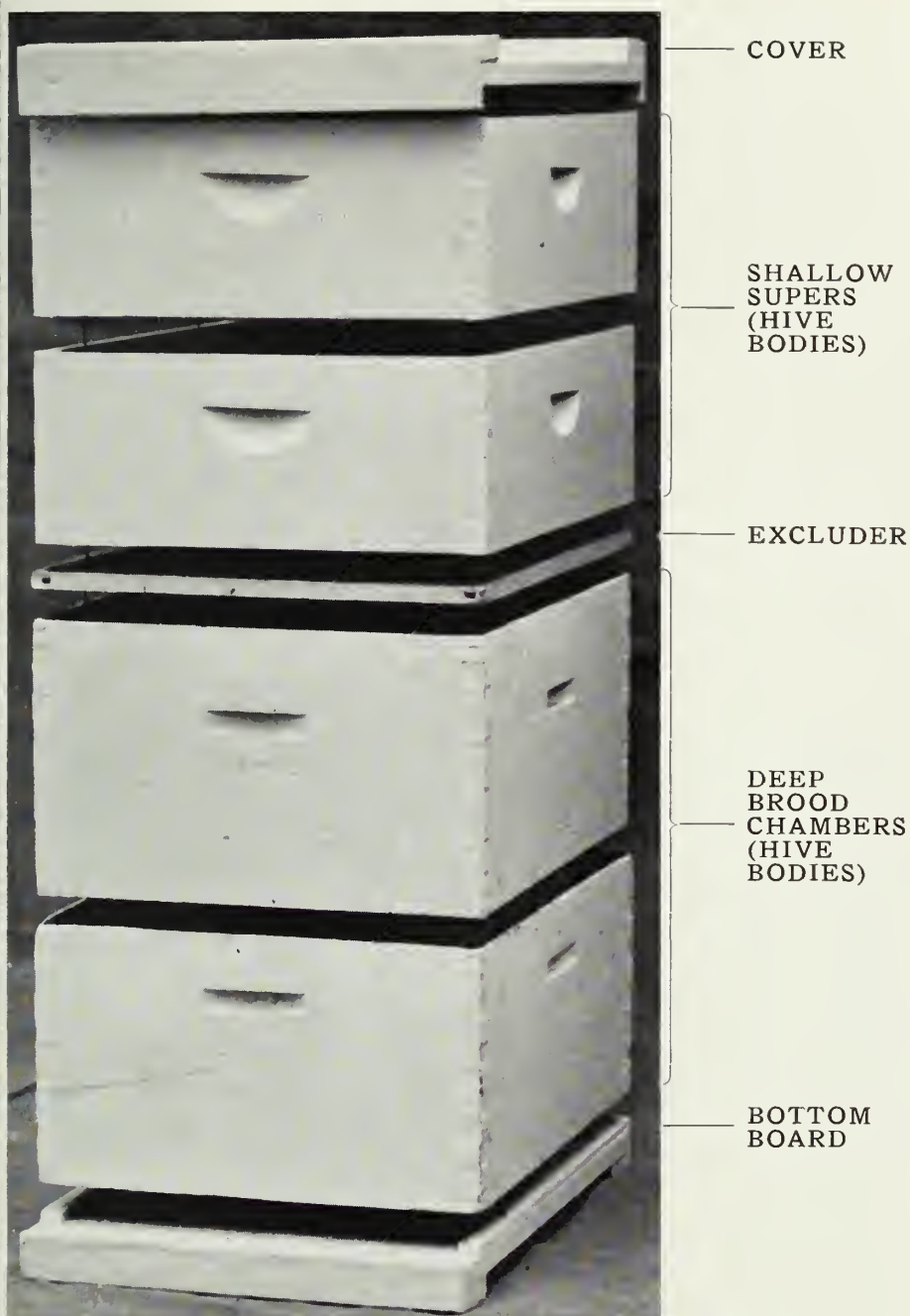
Many beekeeping enthusiasts are attracted by unnecessarily elaborate equipment or feel a need to modify the basic Langstroth design. Most items designed for this purpose are of little value. Knowledge of bees and the ability to manage them are the two essentials of success with bees. It is the strong colony of bees, properly managed, that makes the honey, not some special piece of hive equipment. Use standard items of equipment to enjoy beekeeping to the fullest extent. If you should want to sell or exchange the equipment, you can do so more easily with conventional hives.

Hive Parts and Selection of Equipment

A bee hive is composed of one or more wooden shells called hive bodies within which hang the combs in wooden frames. The space between the cover and the bottom board can be expanded or reduced to meet the needs of the colony during the year. Hive bodies in which a brood nest is located are usually called brood chambers. Hive bodies located above the brood chamber are called supers, simply because of their location above the brood nest. The hive may be made up of any combination of hive bodies of the same or different vertical dimensions, or depths. Traditionally, beekeepers have used brood chambers at least $9\frac{5}{8}$ inches deep, but honey bee colonies will live just as well when given sufficient combs of shallower dimensions. Amateur and commercial beekeepers should seriously consider using hives composed entirely of 10-frame hive bodies $6\frac{5}{8}$ inches deep. They provide complete interchangeability, are lighter in weight, and are easier to manipulate. All the parts of a hive should be the same width, preferably 10-frame. The parts of a bee hive are shown in Figure 12.

Bee hives are available from many different companies (see page 128) or you can make your own. If you prefer to build them, make sure that all dimensions of the hive bodies conform to those of commercially built hives. Otherwise the bees will fasten the parts together so firmly that you cannot manipulate them easily. Hive covers and bottom boards need not necessarily be of the same pattern as commercial ones. Simpler ones can easily be made at home.

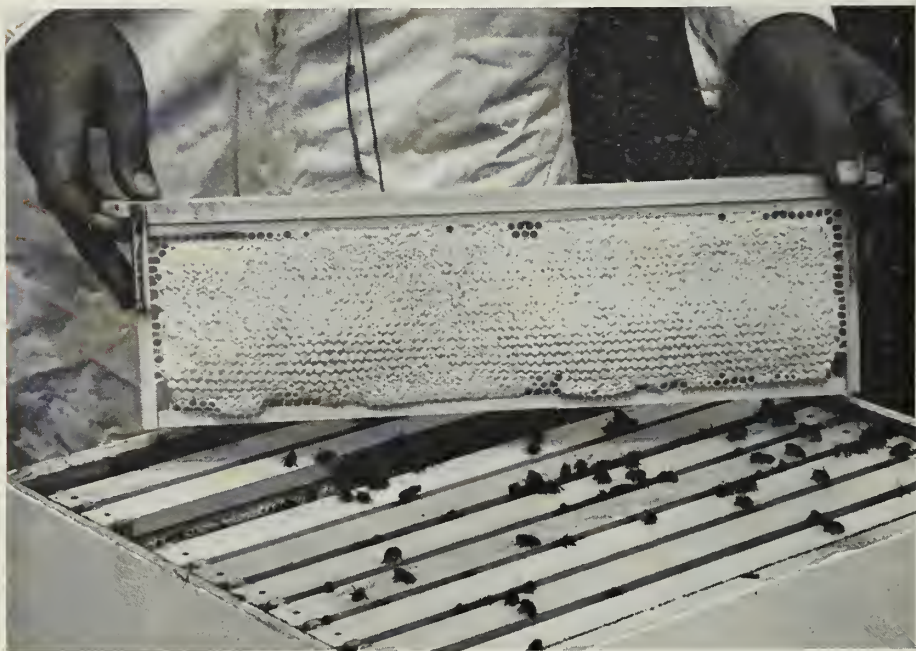
Beekeeping suppliers and catalog stores offer basic equipment kits for beginners. The kits contain only the basic tools and equipment needed to get a swarm or package of bees started and to provide hive space for them for about a month in the spring. Purchase additional equipment at the same time in order to be ready to provide space for the colony to expand during the season. Without additional hive bodies



Parts of a typical bee hive. The parts have been separated and identified for easier recognition. (Fig. 12)

the bees will soon become crowded and swarm. They may never develop a sufficient population and a supply of honey to survive the winter. In that case you will have to start over the next year. If you do it right the first time with adequate equipment, you may soon be wondering what to do with all the honey.

Plan to use at least two $9\frac{5}{8}$ -inch deep hive bodies, or three $6\frac{5}{8}$ -inch deep ones, for the colony brood chamber. Above this brood chamber you need two to four hive bodies, or supers, for honey storage. Avoid comb-honey production in wooden sections until you have gained some experience. Cut comb honey in standard shallow supers ($5\frac{11}{16}$ inches deep) is easier to produce with little or no experience and without the special manipulations and equipment needed for section comb production (Fig. 13). Dadant-depth supers ($6\frac{5}{8}$ inches deep) are a good choice for extracted honey production. They are of a reasonable size to handle and you don't need as many of them as of the standard shallow supers to hold the crop. Many beekeepers in the western states use only deep supers. Although they have to handle heavier units, up to 90 pounds, they handle smaller numbers of units and all the equipment is interchangeable.



A full shallow comb of honey. The comb and frame may be sold as a unit or the comb may be cut into pieces for cut comb or chunk honey. (Fig. 13)

Of the several styles of frames, those with a wedge top bar and split or slotted bottom bar are the least trouble for the beginner to use. He can put the foundation quickly into this frame and it will stay secure when the wedge is nailed in place. The nailless top bar frame is easy to assemble and can be used with plastic-base or metal-bound foundation.

Comb foundation consists of beeswax sheets embossed with the worker cell pattern. When provided with frames containing a sheet of foundation, the bees add additional wax to finish it into a full comb. They must have incoming food, either nectar or sugar syrup, to secrete wax and build comb. Without the available food, the bees may cut holes in the foundation and fail to make it into comb. For this reason you must be sure to feed any new colony started with sheets of foundation. Also, put foundation on established colonies only during a nectar flow or while they are being fed. There are two basic types of foundation distinguished by their relative thickness. Brood foundation, plain, wired, or with a plastic base, is used in deep frames for the brood chamber and in all frames used to produce extracted honey. Its thickness helps make strong comb that can withstand many years of use. The plain and wired foundations make the best combs when placed in wired frames. The comb in an unwired frame may fall out when it is handled on a hot day. Plastic-base foundation with metal ends, and metal-bound, wired foundation produce good combs without any frame wiring. Thin super and cut-comb foundation give the delicate texture to honey that is to be eaten in the comb. They are used without any wires or reinforcement so that the filled honey comb can be cut from the frames ready to eat.

Hive covers come in two basic styles. One is metal-covered and telescopes down over the sides of the hive body (Fig. 14, top). It must be used with a flat inner cover to keep the bees from attaching it too tightly to remove. The two covers provide some insulation and ventilation for the top of the hive. They create problems when the hives are moved because they do not allow the hives to fit closely enough together when tied down on the truck. They are also heavy and their initial cost is greater than that for a plain, flat wood or metal cover. The plain wood cover (Fig. 14, bottom) provides less insulation, but it saves time in opening the colony, stays in place without a weight on top, costs and weighs less, and is best suited for migratory beekeeping.

The hive bottom, or bottom board, as it is called, is also made in two basic types. One is reversible with a deep side and a shallow side to give either a $\frac{3}{8}$ -inch or a $\frac{7}{8}$ -inch entrance to the hive (Fig. 14, top).



A one-story hive with a telescoping cover and a reversible bottom board is shown at top. Another one-story hive with a simple, homemade, two-cleat cover and bottom board is shown in the bottom illustration. (Fig. 14)

The other type provides a $\frac{3}{8}$ -inch entrance and has cleats at front and back that rest on the ground (Fig. 14, bottom). Hive bottoms should be nailed or stapled to the first brood chamber if the hives are moved. Otherwise the hive bodies are just stacked one above the other on the bottom board. Bottom boards will last much longer when treated with a wood preservative such as pentachlorophenol before being painted.

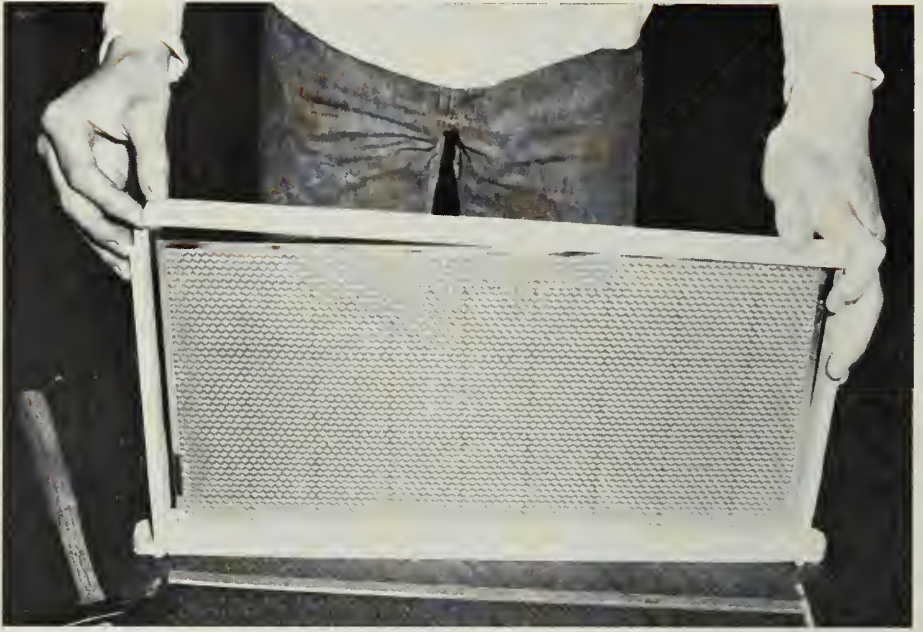
Hives placed on a hive stand, bricks, or other support are a little more convenient to work with and the bees are less bothered by weeds and grass in front of the hive entrances. Hives set on the ground are not damaged if the bottom boards are treated with a preservative, and most commercial beekeepers do not use stands, especially if they move the hives regularly.

Assembly of Equipment

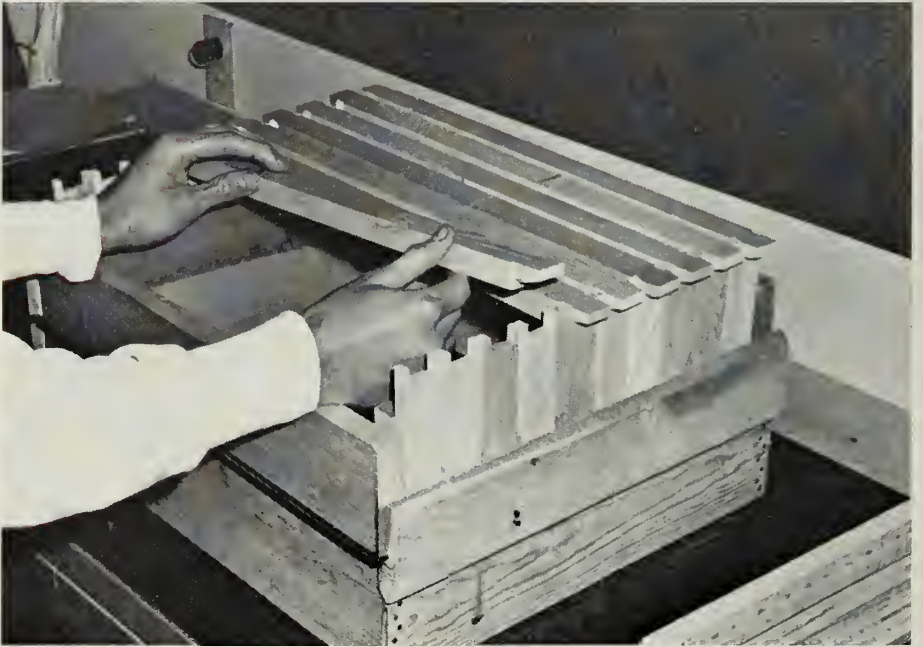
New bee equipment is usually purchased "knocked down" (KD) or unassembled. The directions and diagrams furnished by the manufacturer are easy to follow, but a few details sometimes cause difficulty. A common error is to nail the sides of the hive bodies with the handholds on the inside. The frame rests (shoulders cut into the inside top of the hive ends) also cause some difficulty. They require a metal strip (rabbet) or a small wooden strip to be fastened on top of them to give the proper spacing of the frame.

Frames are made in several slightly different patterns but assembled in the same way. An exception is the nailless top-bar frame (Fig. 15) that locks together on top and requires nailing only on the bottom. You can assemble small numbers of frames individually. For larger quantities, a frame-nailing device or jig will make the job easier and faster (Fig. 16). Drive nails down through each end of the top bar into the end bars and a second pair through the end bars into the shoulder of the top bar (Fig. 17). This cross-nailing greatly strengthens the frame. Glue and power-driven staples are also used to assemble frames. Water-resistant casein glue and other new types are easy to apply with a plastic squeeze bottle. The bottom bar needs two or four nails depending on the style of frame. Frames with one V-shaped edge on the end bars are assembled with the V facing you on the left end and away from you on the right end.

Wiring frames properly is a difficult task for the beginner without some equipment and instruction. It is essential to produce strong combs that will not sag and warp in warm weather or fall apart in the extractor. Thread at least two, and better four, horizontal wires through the ready-made holes in the end bars while the frame is in a



Assembling a nailless top-bar frame with a sheet of metal-bound comb foundation. (Fig. 15)



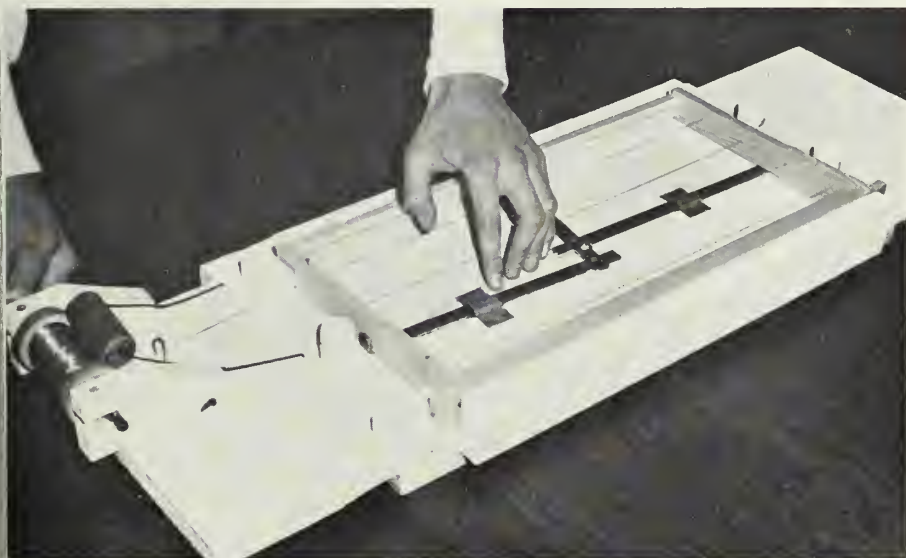
Assembling frames in a wooden jig. The jig is inverted to put the bottom bars in place. (Fig. 16)

wiring device (Fig. 18). Draw the wire tight enough to make a high note when you pluck it. Start and end the wire by wrapping it around a small nail driven into the edge of the end bar. The wire may also be fastened by stapling. Only No. 28 tinned wire is suitable for wiring



Cross-nailing the end and top bars of the frames.

(Fig. 17)



Wiring a frame in a homemade wiring device. The frame is held under tension while being wired; when the tension is released, the wires are tightened.

(Fig. 18)

frames. Plastic-reinforced foundation with metal ends, and prewired, metal-bound foundation can be used in unwired frames.

Fit the foundation into the frame so that the upper edge rests in the notch in the top bar and the lower edge lies in the slot of the bottom bar. Nail the wedge strip so that the nailheads are beneath the top bar when it is hanging in the hive (Fig. 19). Here they cannot later be accidentally hit with an uncapping knife. Place the wired frame and foundation on a board cut to fit within the frame. Roll a heated spur embedder along each wire, pushing it about half way through the wax.



Nailing the foundation cleat in place in a frame.

(Fig. 19)



A simple device for embedding wires into comb foundation. When the copper contacts at each end of the wooden piece touch the wires on the frame end bar, the heated wires sink into the wax.

(Fig. 20)

For large numbers of frames, use an electric embedder with a resistance coil to heat the wires so they sink in the wax (Fig. 20). Use it briefly and carefully at first to avoid cutting the foundation into strips with overheated wires, or melting the wax where wires cross.

Tools, Clothing, and Specialized Equipment

Three essential beekeeping tools are shown in Figure 21. The smoker is your most important tool. With it you are master of the bees as long as you use it properly and keep it lit. The 4 × 7-inch size is the



Three important tools in beekeeping. The bee brush is at the top, the hive tool in the middle, and the smoker at the bottom. (Fig. 21)

best of the three sizes available. Smaller ones are too small even for beginners and the large size is designed for commercial beekeepers.

Hive tools are all-purpose levers for prying hives apart and for scraping. The 10-inch length gives the best leverage when hives are heavy and stuck tightly together.

A bee brush is used to remove bees from combs of brood or honey, particularly those bees that don't come off when the comb is shaken. Since queen cells may be damaged by shaking, a brush is a necessity in queen rearing. If a brush isn't handy, a handful of long grass can be used as a substitute.

It is not necessary to wear extra layers of clothing when working with bees but it is a good practice to dress properly, at least until you gain experience. Bee gloves, either cloth or leather, help to put you at ease in handling frames of bees. Simple gauntlets let you use your fingers more easily than do gloves, yet cover your wrists and the open-



A pair of gauntlets in use. They can be used alone or with a pair of gloves.

(Fig. 22)

ing in your sleeve above the cuff (Fig. 22). A muslin sleeve with elastic in each end makes a good gauntlet. Make it long enough to reach from your thumb to above the elbow. Or cut the toe or foot from a large, white, cotton sock and pull it over your sleeve with the knitted top on your wrist.

White or tan clothing is most suitable when working with bees. Other colors are acceptable but bees react unfavorably to dark colors and fuzzy materials. Be especially careful to cover your ankles or wear light-colored socks. Angry bees often attack ankles first because they are at the level of the hive entrance. Any bee on the ground tends to crawl upward and may go up your leg with peaceful intentions until you squeeze her. Use bicycle clips, inner-tube bands (Fig. 23), or string to fasten your pants legs.

A folding wire veil or a round wire veil, worn with a hat, is a good all-purpose choice for the beginner. A nylon-fabric veil is cool and easy to carry, but it is more easily damaged in use. Wear the veil on a hat with a wide brim and pull the excess material away from your neck when putting it on (Fig. 24).

A queen excluder is a grid of accurately spaced holes or wires through which workers can pass, but not queens or drones. The steel-wire excluders, either metal or wood bound, are best. The zinc ones are suitable only for temporary use or for special purposes such as making cages or covering hive entrances.



An inner-tube band for closing pant legs when working with bees. The band closes and pulls down the pant leg.
(Fig. 23)



A nylon net veil worn with a straw hat to keep the veil away from the face. Note how the excess material is pulled away from the neck. (Fig. 24)

Always use standard hives without modification or accessories. Special bottom boards and covers, queen and drone traps, and other similar equipment usually increase the cost of keeping bees without providing proportionate returns. It is proper management, not specialized equipment, that leads to success in beekeeping.

SPRING MANAGEMENT: STARTING WITH BEES

When and How to Start

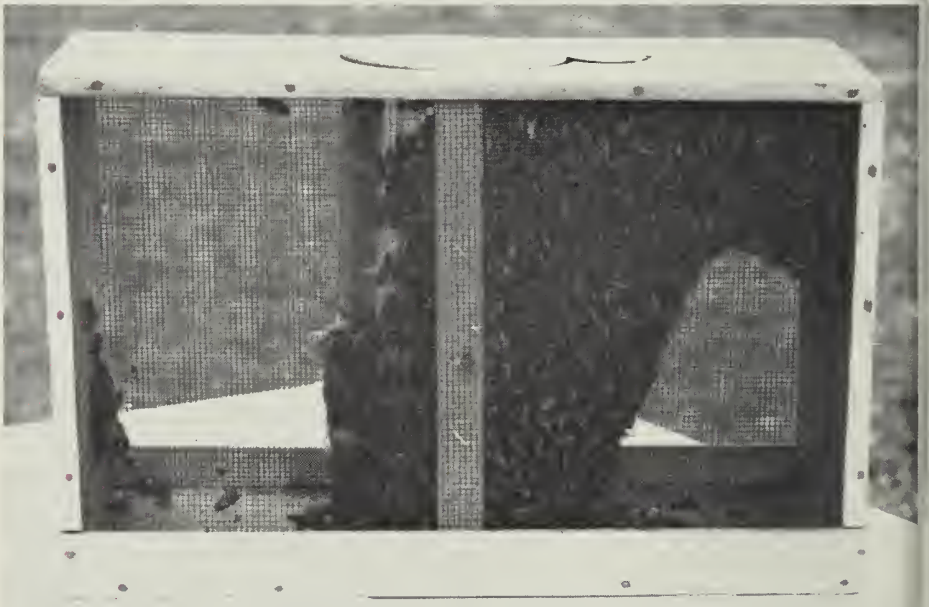
Spring is the ideal time to begin keeping bees. In Illinois the best months for this are April and May, depending on the area of the state, when fruit trees, dandelions, and early flowers are in bloom. The reasons for starting at this time are that the spring blossoms and the lengthening days help to get the bees off to a good start and the early start allows the colony to increase its population in time to store honey from the clovers that begin to yield nectar about the first 2 weeks in June in central Illinois.

Established colonies. A beginning beekeeper should start with at least two colonies but not more than four or five. With more than one colony you have the advantage of being able to exchange brood, bees, and combs in case one of the colonies needs some help. With too many colonies you may have only enough time to keep them supplied with supers, and not be able to enjoy learning the details of the activities in any of them. The beginner can purchase established colonies from a local beekeeper but he should do so with care. Hives offered for sale may be homemade, with poor combs and, sometimes, the bees may be diseased. There is nothing wrong with good homemade equipment built to proper dimensions, but hive bodies and frames made without regard for the proper bee space are worthless. The amount of honey in the hive that you buy is not as important as the quality of the equipment as long as there is at least a small reserve supply. The bees themselves can be improved at slight expense by requeening the colony. Buy established colonies only after they have been inspected and found free of disease by an apiary inspector from the Illinois Department of Agriculture.

If you buy full-sized colonies, you will lose the opportunity to watch the fascinating early development of the colony that you have if you buy package bees or small nucleus colonies of three to five frames. Also, newly established small colonies are easier for the beginner to observe and manipulate than are the larger ones. In part, this is because of his reaction to the number of bees present and also because

of the greater number of guard bees and field bees in the larger colony. They are not necessarily meaner, but more bees react when large colonies are handled. Consider this difference when you begin with bees because it is essential that you open the hive regularly and learn about the inside activities of the colony.

Package bees. Package bees (Fig. 25) are shipped in screened cages from apiaries in the southeastern United States and in California. Order them early, in January if possible, in order to have the best chance of receiving them on time, preferably in April. A 2-pound package with a queen will produce as good a colony as a 3-pound package if it is fed well and gets off to a good, early start. If a package colony is put in a hive completely filled with foundation, it must be fed continually with sugar syrup for as long as a month. Package bees installed on combs must also be fed unless there is considerable honey in the combs. The food will not be wasted because it will be used to produce combs and to feed developing young bees. Spring flowers and spring weather cannot be depended upon to provide natural food for such colonies. Use syrup made from equal volumes of water and granulated white beet or cane sugar. A gallon can or large jar above the colony makes a better feeder than the entrance type. (See page 79.)



A 2-pound package of bees.

(Fig. 25)

Package bees usually are shipped with instructions for placing them in the hive. The bees are not difficult to handle if you remember some important fundamental details. A complete one-story hive must be ready to accept the bees and a location must have been chosen for it. Pick a spot where the hive will get sun at least during the morning. Afternoon shade makes life easier for the colony in hot weather. Leave room on at least one side of the hive to give access to it, and keep it away from clotheslines, walks, and other areas where people must pass by. Hedges or fences screen the bee hives from neighbors, and will also make the bees fly higher so that they are less likely to bother people. If you have a choice, face hives south or east and away from areas of human activities.

When the package arrives, put it in a dark, cool place such as a basement until you can install the bees in the hive. As long as they have food they can be kept in the package for a day or two if necessary. Late afternoon is the best time to install them so that the bees will settle down quickly without flying very much. When you are ready to start, place the cage on its side and spray, sprinkle, or brush warm sugar syrup on the screened cage sides. Use only as much syrup as the bees will clean up readily.

When you are ready to install the bees, put on your veil, get your hive tool, and place the hive on location with five frames set to one side of it. A smoker is rarely needed but you should have it ready. Also have the cover and the equipment ready to feed the bees after they are installed. Stuff the hive entrance lightly with green grass or reduce its size with an entrance cleat. Sprinkle or spray the bees through both screen sides of the cage with enough lukewarm water to thoroughly wet them. Loosen the cover of the package but do not remove it. The queen cage is usually beside the syrup can at the top of the package or hanging by a wire or tin strip below the can. Give the package a sharp bounce on the ground to knock the bees to the floor. Remove the syrup can and queen cage and replace the cover over the hole. Expose the white candy in the queen cage by removing the cork or other covering from the small hole in the candy-filled end of the cage. Then wedge the cage, candy-end down, between two frames in the center of the frames in the hive. Bounce the cage again and pour the bees into the empty space in the hive, shaking the cage back and forth to dislodge the bees and to get them out of the cage. You may have to repeat this procedure several times until no more bees will come out. Leave the cage beside the hive entrance overnight with the hole beside the entrance and touching the bottom board. If the queen cage contains only

a queen and no candy, or if you want to use the fast release method, shake the bees into the box as described above. Then sprinkle syrup on the queen cage to wet the queen and prevent her from flying. Hold the queen cage down in the hive, remove the screen, and drop the queen among the bees. When the queen is in, quickly but gently replace the frames in the hive, put the feeder in place, and leave the hive alone for at least 5 days. Then, on a warm afternoon, take a brief look at the colony. Use only a little smoke and handle the bees and equipment gently. Look primarily for eggs and larvae that indicate the queen has been accepted and is laying. Remove the queen cage after checking it to be sure it no longer contains the queen. Close the hive quietly after replenishing the syrup supply.

Nucleus colonies. Another way to start is to purchase a nucleus, a complete small colony (Fig. 26). A nucleus, with three to five frames of brood, bees, and a queen, compares in price with package bees and has the advantage of having developing bees that will quickly increase the size of the colony. In purchasing nuclei locally, be sure they are from colonies that have been inspected for disease. The frames



Opening a small hive, or "nuc box," containing a three-frame nucleus colony of bees.

(Fig. 26)

of brood and bees can be placed into your prepared equipment with or without an exchange of frames. The colony will need incoming nectar or sugar syrup until all its combs are completed.

Other sources of bees. Honey bee colonies, together with their combs, can be transferred from a tree or house into a modern hive. However, because of the amount of work involved and the difficulty of obtaining good combs, you should avoid this method of obtaining bees unless you have no alternative. Swarms also can be used to establish your first colony or to provide additional new colonies for your apiary. They are not usually available as early in the season as package bees, which are more suitable for an early spring start. Most swarms contain old queens that should be replaced during the summer.

Location and Arrangement of Colonies

The location and arrangement of an apiary is important to the bees, to the owner of the bees, and to the people and animals close by. Bees are affected by the exposure of the hive in relation to wind, sun, and the surface on which the hive is placed. Protecting hives from prevailing winds, especially in winter, will result in stronger colonies. Hives should be located so that the sun hits them at least in the morning and early afternoon. In Illinois, colonies are rarely damaged by being in full sun, but afternoon shade is beneficial. With shaded hives, the bees may forage better because fewer bees are required to cool the hive and to carry water for evaporation. Reflected heat from around the hive also affects the colony. Grass or other ground covers reflect less heat than exposed soil. Asphalt areas or tarred roofs are not suitable sites for hives.

Traditionally, hives in apiaries have always been arranged in straight rows. It is much better to place the hives in some irregular pattern so that field bees are more likely to return to their own colony. With hives in a straight row, foragers drift to the end hives and increase their population at the expense of the colonies in the center of the rows. For convenience, the hives can be arranged in pairs about 5 inches apart. Pairs of hives can be separated from one another by several feet. A semicircle or U-shaped arrangement reduces drifting and makes it easy to handle the colonies with a hive loader.

Flowering plants within about a mile of the colony are important to its success. A good apiary location should have spring nectar and pollen plants as well as plants that provide the main nectar source later in the year. Ornamental trees and shrubs provide early pollen and nectar for bees in or near cities and towns. As a result the colonies develop faster

than in areas of open farmland. Later in the season a farm-based colony may have the advantage of more clovers and other crops that produce nectar. Remember this difference if you have to choose between two locations. Also consider the possibility of moving hives to take advantage of different areas with more available nectar and pollen plants. There is a saying that, "Good locations make good beekeepers." Commercial beekeepers must seek and test new locations regularly.

When locating the hives, you also need to consider the conditions under which you will have to work with the bees. Just keeping the bees in a sunny spot will help because they will be easier to handle if the colony is warm and flying well. Don't put hives under a tree or in similar spots where you cannot stand comfortably to open them. Since you will manipulate the hives from the side, leave space on at least one side for standing and for handling equipment. You will enjoy the bees most if you look within the hive regularly—at least weekly in good weather. For this reason, keep hives as close to home as possible where you can observe them readily. Obviously, not everyone can keep several colonies in his backyard, but you are more likely to find the time to master them if they are close by.

A final consideration in locating your colony is an important one. Bees can be a nuisance in several ways wherever they are kept. However, you can reduce or prevent problems by planning ahead. Bees are liable to sting people and animals in the vicinity of their hive and in the flight path between it and the plants they visit. To offset this



A honey bee waterer filled with crushed rock. A float valve controls the flow of water from a tank to which the waterer is connected by a hose.

(Fig. 27)

tendency, try to screen the hive or apiary to make the bees fly above the heads of passersby. Bees also spot cars, clothing, and buildings in the vicinity of the hive by releasing their body wastes in flight. Spotting from a single colony is not serious but several colonies flying largely in one direction may make a car or a house unsightly in a short time. When nectar is not available bees cause problems by visiting sources of water such as water faucets, children's wading pools, and bird baths. Once they become accustomed to a watering place, they will continue to use it all during the flying season. Water must always be available close to the hives, starting the day a colony is established or moved. Provide a tank or pan with something in it on which the bees can land. Cork floats or crushed rock can be used for this purpose (Fig. 27). A hose or faucet dripping onto a board or cement slab is also suitable.

Handling the Colony

The beginner with bees is naturally reluctant at first to spend much time looking at his colony within the hive. He is usually a little over-cautious about handling the bees and also about damaging the colony. With proper clothing and equipment there is no reason to hesitate. And don't worry about the colony—they can be damaged far more by neglect than by too much attention.

If you have been stung by a bee without more effect than the usual swelling, you have little to worry about in handling a colony. A few people, however, react strongly to bee stings and may have trouble breathing; they may even go into shock or unconsciousness. When this happens the person should be taken immediately to a doctor for treatment with adrenalin (epinephrine). The effect of a bee sting can be reduced by promptly removing the stinger. Do so by scraping it off, being careful not to squeeze it and drive additional venom into the skin. When you are stung while handling bees, quickly remove the sting and smoke the spot. The smoke repels bees and covers the odor of the sting that otherwise may attract bees to sting the same spot. It is also a good idea to smoke your hands before you begin handling a colony.

Before opening a hive, you need to light the smoker. It is essentially a firebox with a grate and a bellows. To work properly and to provide thick, cool smoke it must have coals above the grate and unburned material above them. A burlap sack cut into strips makes good smoker fuel. Rotten or pitchy wood, corn cobs, and shavings are also suitable. Light a small quantity of fuel and puff the bellows until the material flames. Add more pieces, while puffing the bellows, until the barrel of the smoker is full but not packed tightly. Once started well, a smoker

will not go out when you need it. Refill it and pack it down with your hive tool as you work. Keep the smoke cool and thick.

After putting on your veil, approach the hive from the rear and work from either side. If several colonies or rows of colonies face the same direction, examine the front hive or row first so that you later work behind the disturbed colonies. Avoid jarring the hive or setting the smoker on it before opening the hive. Blow several puffs of smoke into the hive entrance and into any other hive openings such as auger holes or large cracks through which bees can crawl. The smoke repels and distracts the guard bees. Pry the cover up slowly with the hive tool, hold the edge up a few inches, and blow two or three puffs of smoke beneath it. A little smoke goes a long way with most colonies so use it sparingly unless you find the bees flying at your hands and clothing. More smoke is usually needed in cool weather.

Once the cover or a hive body is lifted, remove it without letting it back down in place. In this way you crush fewer bees and alarm the colony less. Place the cover, underside up, on the ground close beside you toward the rear of the hive. In this position it serves as a place to put the second story when you look at the bottom brood chamber of a two-story hive (Fig. 28). If you want to look at both hive bodies, separate them, using smoke, and look at the lower one first. Otherwise many bees move to the lower body and make it harder for you to examine the combs. Smoke the bees in the top hive body before you put it back on the lower one.



Examining a two-story colony of bees. The top hive body has been placed on the inverted cover at the rear of the hive. A frame on the edge of the brood nest is being removed. (Fig. 28)

With the cover off, you should be able to see the area with the greatest number of bees, especially in a package colony or nucleus. This area is the brood nest where the queen and developing bees are located. To look at the colony, you must first loosen and remove a frame at the edge of the brood nest or, in large colonies, the first or second frame from the edge of the hive (Fig. 28). Pry the frames apart with the straight end of the hive tool. New frames separate easily, but you may have to force older ones apart at the end bars in order to break the bits of comb and propolis holding them.

Pull the first frame slowly out of the hive, look briefly for the queen and, if she is not on the frame, set it on end against the opposite



Placing a frame beside the hive before examining the lower brood chamber. The hive tool is kept in the hand when manipulating frames, and the smoker is held between the legs ready for use. (Fig. 29)

side of the hive near the entrance (Fig. 29). If the queen is on the frame, it is better not to set the frame outside the hive where she may fall on the ground. The rest of the frames can then be examined and replaced in order. Hold the combs above the colony when looking at them, with the comb surface vertical. Pollen and nectar may fall from combs held horizontally. To look at the opposite side of a comb, raise or lower one end until the top bar is vertical. Pivot the frame 180 degrees and bring the top bar back to a horizontal position. Repeat the process before replacing the comb in the hive. Put the first frame back in its original position.

One application of smoke usually lasts for several minutes. Then you may notice bees lining up along the tops of the frames looking at you. Before they decide to fly at you, give them a puff or two of smoke to drive them back down. To close the hive, smoke the bees at the top of the hive, strike the cover on the ground in front of the colony to knock off adhering bees, and lower the cover slowly into place. When putting any equipment with bees in it back together, pause slightly just before the parts touch; most of the bees will move out of the way.

The standard hive holds 10 frames with a little extra space when they are new. In a short time, additional wax and propolis make it difficult to remove the individual frames. It is better to violate the bee-space concept and use nine frames than to fight with tightly stuck frames. The 18 combs of a two-story brood chamber give the queen plenty of room in which to lay, and the thicker combs of honey in the supers are easy to uncap. Full hive bodies of foundation, whether for brood combs or for honey production, should contain 10 frames. The extra brood comb can be removed later when it is completed. Use nine frames per hive body when only a few frames of foundation are added, and push the frames together toward the center of the hive. With the wider spacing the bees may build undesirable comb between the sheets of foundation.

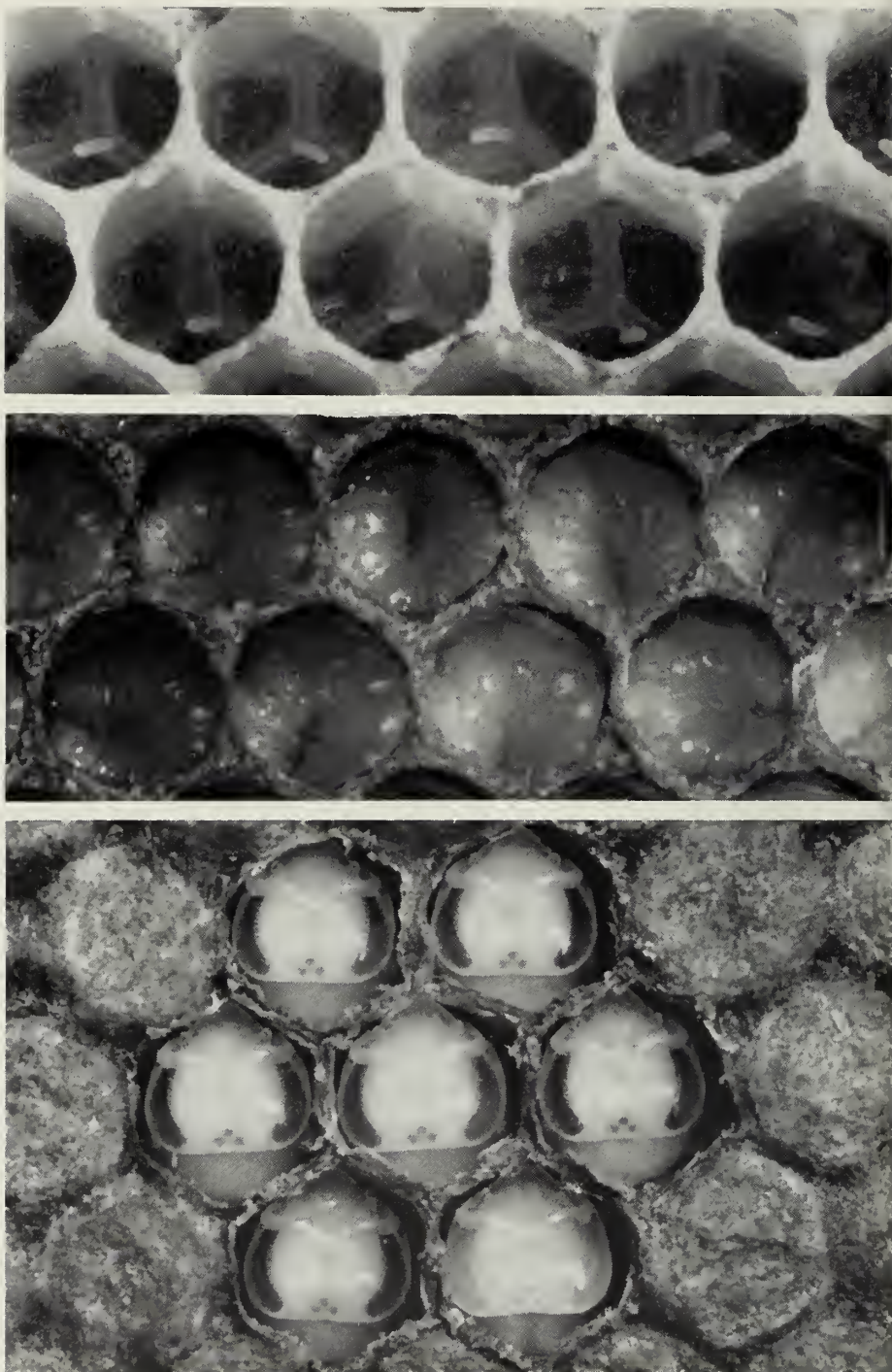
What to Look for in the Colony

Above all, most beekeepers want to see the queen bee in the colony. Finding her is usually easier in a small colony than in a large one. In either case, she is sometimes elusive and may be found on the wall of the hive or on the bottom board instead of on the combs. You can find the queen most easily by smoking the colony lightly and looking quickly at all the combs within the brood nest. She is often found on a comb containing eggs, or on one with the cells that have been cleaned and are ready to receive eggs. The quality of the queen can be judged without

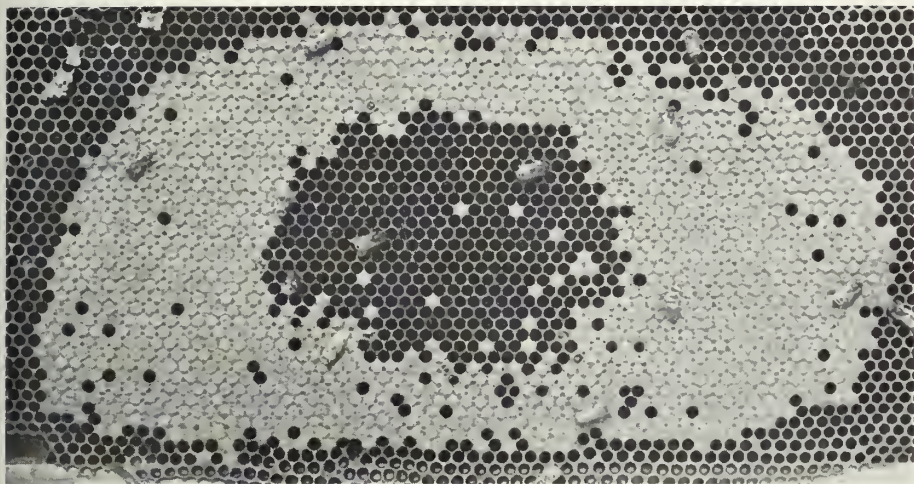
seeing her by the pattern in which she lays her eggs in the comb. Large solid areas of sealed brood, and concentric rings of eggs and larvae of different ages are the signs of a good queen. It takes practice to recognize eggs and young larvae at the base of the cells; learn to identify them readily. (See Figure 30.) Shake the bees off a frame into the hive in order to see details in the comb more easily. You can make the bees move away from an area of comb by touching them lightly on their backs with your finger or the flat end of a hive tool.

The brood pattern should be solid, with few open or unused cells (Fig. 31). A spotted pattern may indicate that the queen had a sex allele the same as one or more of the drones with which she mated. Such a queen should be replaced. The egg-laying behavior of the queen may produce a spotted brood pattern when she does not fill all the adjoining cells with eggs. She also should be replaced. Brood diseases kill larvae and pupae and create an uneven, spotted appearance of the brood combs. As explained in the section on diseases, you must learn to detect diseases or, at least, to recognize abnormal larvae and pupae. (See page 101.) By doing so, you will know when to ask for help in identifying the disease, or you may be able to diagnose it yourself by comparing the symptoms with the descriptions of brood diseases. Proper diagnosis and control of disease, especially American foulbrood, is extremely important in beekeeping. Otherwise you may lose all your bees and spread infection to other people's colonies that are within flight range of your apiary.

The colony needs pollen and honey in the hive all year as food for the adults and for rearing young bees. It has been estimated that a full cell of each type of food is needed to produce one young bee. The pollen supplies proteins, vitamins, and other minor nutrients. Honey provides carbohydrates in the form of several sugars. The honey removed by man from his hives must be only the *surplus* produced by the colony. If more than that is taken, or if it is taken at the wrong time, the bees may starve. A beekeeper must learn to estimate the amount of food, particularly honey, in the hive at each observation and to decide whether the colony is "making a living" or needs some help until more nectar is available. Learn to do this each time you open your hives, especially package colonies or any small colony just getting started. In early spring the bees may be unable to fly for a week or more because of cool or wet weather. At this time, and any time before the major nectar flow period, a colony needs 10 to 20 pounds of reserve food or the equivalent of two or three well-filled combs. You can test for incoming nectar in the hive by holding a comb flat above the open hive and giving it a quick shake downward. Any thin nectar in the



Eggs in new worker comb are shown in the top illustration and mature worker larvae nearly ready to be sealed in their cells are shown in the center. The bottom illustration shows worker pupae with their eyes colored. The cell cappings in the bottom illustration have been removed to expose the developing bees. (Fig. 30)



A comb from the brood nest showing a good pattern of sealed brood. Young bees have emerged from the center cells. The queen will lay eggs in the center cells as soon as they have been cleaned and polished. (Fig. 31)

comb will splash down onto the tops of the frames where it will be reclaimed by the bees.

When nectar is not available in the field, bees attempt to steal honey from other colonies. The guard bees of strong colonies attack and repel the robbers, but weaker colonies are sometimes overcome and killed by large numbers of robbing bees. The problem is most serious in the spring and the fall at any time hives are opened and combs exposed to bees. The natural defense system of the colony is disturbed by smoke and by the separation of the parts of the hive. Bees from other colonies are attracted and they fly around the exposed combs trying to get some of the colony's stored honey. Even after the hive is put back together, the robber bees may gather along the edges of the cover and other cracks in the hive. They will also try to get into the entrance of the colony as well as other nearby colonies. A beekeeper must learn to recognize the presence of robber bees and to take action to prevent the buildup of widespread robbing. This means keeping hives open only briefly and being careful not to expose combs, especially ones not protected by bees. It is easier to prevent robbing than to stop it. Always pick up bits of comb in the apiary and try not to let nectar or honey drip outside any hive. Robber bees can be recognized by their darting flight around combs and open hives, often with their legs hanging down. They land on combs and move quickly to cells of honey to fill up. If you see robbing starting, it is a good idea to stop looking at the bees and close the hive. As a precautionary measure, you

can stuff grass or weeds lightly into the entrances to reduce their size. With smaller entrances to guard, the bees of a colony are better able to repel robbers.

The brood nest of the colony is an oval or circular area within the frames. The comb in the center of the brood nest has a large area of brood on each side. The combs toward the outer edges of the nest have smaller and smaller brood areas until the ones on the edge of the nest have only pollen and honey without brood. It is important to keep these combs (frames) in order in a small colony, especially when the temperature may go below 57°, the clustering temperature of a colony. If you put a large frame of brood near the edge of the cluster, the bees may not be able to keep it covered and warm because the shape of the brood nest has been changed. Eggs and developing bees can be injured or killed by being chilled. In large colonies, and during warm weather, the order of the combs is not as important. However, it is best to keep brood combs together, with combs of pollen and honey on the edges and above the brood nest.

The Need for Space in the Spring

The colony increases rapidly in size in April and May. It needs room for brood rearing, for storing honey and pollen, and for the increasing number of adult bees. Since one of the primary causes of swarming is crowding of adult bees, the colony should have two or more full-depth hive bodies or their equivalent to reduce the chance of early swarming. The package colony or nucleus needs a second hive body as soon as most of the foundation has been drawn into comb, and bees cover eight or nine frames in the hive. It has been estimated that a 10-frame hive body provides room for about 15,000 adult bees. If this is correct, the growing colony needs at least two hive bodies, and a full-sized colony containing about 60,000 bees needs four hive bodies just for housing the bees.

Spring Management of Overwintered Colonies

There are some additional items to consider in management of overwintered colonies. Most important is the early spring check on stores. The first time the temperature reaches about 60° in January or February, open each hive briefly to see if it has sealed honey near the cluster. In central Illinois this can usually be done by mid-February. If the cluster is surrounded by combs with sealed honey visible at the top, leave it alone, replace the cover, and put a brick or rock on it. But if the colony is against one side of the hive or lacking visible food, you

should make some changes. Remove a comb with honey from the opposite side of the hive, pry the frames with the cluster away from the hive side, and insert the honey. Without this adjustment the cluster of bees may contract away from food during the next cold period. When the colony needs additional food, you can exchange combs with a well-provisioned hive or feed the colony with fondant or dry sugar. (See page 78.) The period of late winter and early spring is a crucial one for bees because brood is being reared and honey consumption is greatly increased to keep the brood nest warm and to feed the developing bees. Most losses from starvation take place during this period — not during the middle of winter.

There is a natural winter loss of bees despite good management. If you find a dead colony, close the entrance and take it out of the apiary as soon as possible. This prevents robbing, damage to combs, and the spread of any disease that may be present. After being freed of dead bees, the hive and combs can be used to start another colony or for supers. Inspect them first for symptoms of disease before reusing them.

The first thorough colony examination should be made on a day when the temperature reaches about 70°. Look first for the queen or for brood. The absence of brood in a small colony is normal but a colony covering six or eight combs should have young bees and brood. Look at the brood to see if it is normal, without disease, and with no drones in worker cells. Consider the honey reserves and plan to feed the colony if there are less than several full combs of honey.

As the weather continues to warm up in April and May, you can complete your spring beekeeping chores. Most colonies wintered in two hive bodies move to the top one during the winter and most of the brood is there in the spring. Move this brood and part of the stores to the lower brood chamber or reverse the hive bodies. The frames must be moved in hives with the bottom boards nailed on. At this time you should clean off the bottom board and replace any empty combs that have large areas of drone cells. Place part of the combs containing honey above the brood nest with several nearly empty combs between them. Remove all winter packing materials at this time. Any preventive treatments for disease may be applied after careful inspection for disease.

Pollen Feeding

Pollen is essential for rearing young bees and developing strong colonies. Newly emerged adult bees also need pollen to eat. In late

winter the colony uses pollen that was stored the previous year. If there is little stored pollen, the colony will not die but its growth will be hindered until fresh pollen is available in the field. Feeding pollen or pollen substitutes in February and March stimulates the bees to build strong colonies early in the season. If you want to make additional colonies by dividing, or need strong bees for fruit pollination, consider feeding a pollen mixture to the bees. However, unless you can use the extra bees, you may only create a swarming problem and a feeding problem for the extra bees that require food until nectar is available in quantity.

Honey bees have such a strong urge to collect pollen in the spring that they create problems when they visit farm feedlots for bran and ground corn. A dry pollen mixture placed in the apiary in February and March will help to satisfy this need and may keep the bees at home. Once started, the feeding should continue without interruption until natural pollen is available.

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SUMMER MANAGEMENT: HONEY PRODUCTION

Nectar and Pollen Plants

One reason for the success and adaptability of the honey bee is its willingness and ability to use the nectar and pollen from thousands of plant species of all types. The intermediate body size and tongue length of honey bees as compared with other bees enable them to utilize many different types of flowers to obtain nectar and pollen. Although their tongues are shorter than those of most bumble bees, they are long enough to reach nectar in flower tubes several millimeters long. Honey bees also visit tiny, open flowers that are too small for larger bees.

In general, honey bees must depend for their nectar and pollen on wild plants, or on cultivated plants grown for food crops, pasture, or other purposes. The yield of nectar is not sufficiently large to justify planting crops only for bees. However, there are many ways in which plantings made for other purposes can benefit bees. Agricultural land diverted from production can be planted to clovers and other legumes useful to bees. Shrubs, trees, and annual plants used for recreation and conservation areas can provide beauty and pleasure for people, seeds and berries for wildlife, and nectar and pollen for honey bees. Road-side plants used to reduce maintenance and to control erosion can also provide forage for bees.

Supplies of nectar and pollen are important to bees all year, but especially so in the spring. At this time the food reserves in the hive are usually low and the demand for food to feed the rapidly developing young bees is high. Cool and wet spring weather often limits flight and thereby retards the growth of the colony. It is unusual for colonies to produce surplus honey from early-blooming plants such as tree fruits, berries, dandelion, mustard, and willow. However, if colonies have enough field bees, and the weather is good, they may store surplus honey from these early nectar sources. Such surplus should not be removed because it is used by the colony for food until the main nectar flow later in the year. Bees secrete wax and build combs from foundation well during a spring nectar flow. However, unless you also feed the bees, do not try to put a full super of foundation on a colony in the spring. Two or three frames are usually enough.

Honey bees visit large numbers of plant species at any one time and throughout the foraging season. The system of communication within the colony tends to concentrate the foragers' efforts on those plants that give the greatest quantity of nectar and pollen, and have the highest concentration of sugar in the nectar. A plant that is highly attractive to bees when nectar is scarce may not be visited when other more desirable plants are in bloom. When we speak of nectar and pollen plants, we include all plants visited by bees. Most of them are not of primary importance to bees and are classified as minor sources of pollen and nectar. The major, most important, nectar and pollen plants are the few that grow in abundance, usually within a mile and a half of the colony, and provide a fair return of pollen and nectar per flower head or individual floret. An English study of pollen collection by bees indicated that plants offering fair amounts of pollen must be growing within $\frac{1}{4}$ mile of the hive to be visited by bees. The greatest amount of pollen was collected from the main nectar sources and from those most abundant near the hive. In general, this is also true in Illinois.

The primary or major nectar and pollen plants of Illinois, based on their yield and value to honey bees, are:

True clovers, <i>Trifolium</i> species	Sweetclovers, <i>Melilotus</i> species
White dutch — <i>Trifolium repens</i>	White sweetclover — <i>Melilotus alba</i>
Ladino — <i>Trifolium repens</i>	Yellow sweetclover — <i>Melilotus officinalis</i>
Red clover — <i>Trifolium pratense</i>	Soybean — <i>Glycine max</i>
Alsike clover — <i>Trifolium hybridum</i>	Dandelion — <i>Taraxacum officinale</i>

Secondary nectar and pollen plants are:

Alfalfa — <i>Medicago sativa</i>	Maple — <i>Acer</i> species
Aster — <i>Aster</i> species	Milkweed — <i>Asclepias</i> species
Berries, black and others — <i>Rubus</i> species	Mustard — <i>Brassica</i> species
Chicory — <i>Cichorium intybus</i>	Smartweed — <i>Polygonum</i> species
Corn — <i>Zea mays</i>	Spanish needles — <i>Bidens</i> species
Elm — <i>Ulmus</i> species	Sumac — <i>Rhus</i> species
Goldenrod — <i>Solidago</i> species	Sunflower — <i>Helianthus</i> species
Lima bean — <i>Phaseolus lunatus</i>	Tree fruits — apple, apricot, plum, cherry, pear
Locust, black — <i>Robinia pseudo-acacia</i>	Vine crops — cucumber, muskmelon, pumpkin, squash, watermelon
Locust, common honey — <i>Gleditsia triacanthos</i>	Willow — <i>Salix</i> species

Plants in extreme southern Illinois bloom as much as 3 or 4 weeks before those in extreme northern Illinois. The dates referred to here are those for central Illinois. In mid-March, the first sources of pollen

and nectar are the maples, elms, and willows. Early fruit bloom, such as apricot, begins in April, and apples are usually still blooming in May. Dandelion comes early in protected spots but reaches its peak bloom in May. Its nectar, and that from white Dutch clover and sweet-clover make up the primary nectar flow until about mid-July. At that time, red clover (Fig. 32) and soybeans (Fig. 33) are visited for nectar and pollen as the more attractive clovers go to seed and cease to yield food for bees. Late-blooming, full-season soybeans, such as Clark, Kent, and Wayne, are of most value to the bees. Soybeans are classed



Forager collecting pollen and nectar from red clover blossoms. The bee's pollen load can be seen in the pollen basket on her rear leg.

(Fig. 32)



Honey bees visit soybeans for nectar and pollen as the clovers become less attractive in July and August.

(Fig. 33)

as a major nectar source partly because of the 5 to 6 million acres available to bees in Illinois. Red clover provides large quantities of pollen and worthwhile amounts of nectar from second crop bloom. In central Illinois, chicory is an important source of pollen and probably also gives some nectar. In other countries it is considered a good nectar source but in this country it has generally not been recognized as such.

Smartweed, spanish needles, and aster are the latest blooming of the more important plants. They may yield nectar in August and September, depending upon the weather and the soil moisture.

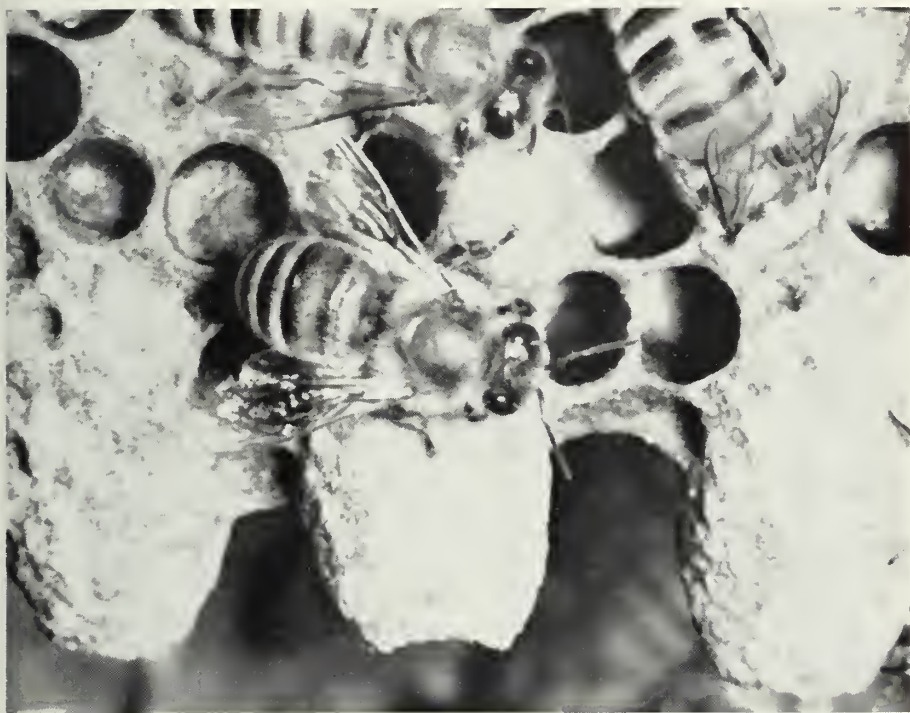
Honey bees also collect two other materials from plants. One of these is called honeydew. It is excess plant sap excreted by aphids and other insects that feed on plants. It is most common on trees such as willow, elm, pine, and oak, but may also occur on alfalfa and other crop plants. The other material is called propolis. It is a plant resin or gum collected from buds and other plant parts of trees such as poplar and ash. The bees pack it onto their hind legs but must have help to remove it in the hive. They also collect and reuse propolis from used beekeeping equipment stored in the open.

When nectar is not available, usually in the fall, bees collect a wide variety of sweet substances. They suck the juices from apples, pears, grapes, and other fruits that have cracked or been opened by other insects or by birds. Bees create problems when they visit sugar syrup at canneries, root beer and other drinks at drive-in restaurants, and even baked goods with jam-like toppings displayed in open stores.

Swarming and Swarm Prevention

Swarming is the natural method of propagation for honey bee colonies. Natural selection has favored the maintenance of the swarming trait because those colonies that did not swarm died without leaving new colonies to carry on. For centuries man has selected bees that produced the best swarms to increase his number of colonies. The use of movable frame hives now enables us to divide colonies at will, and we must try to prevent or control swarming because it weakens the colonies and reduces honey production.

A swarm consists of the old queen, some drones, and 50 to 90 percent of the worker bees of a colony. They leave the colony suddenly as a group and cluster temporarily on some object such as a tree branch. Later they disperse and move to a new home selected for them by scout bees. Sometimes several swarms from one hive leave over a period of a week or more, and many of them are accompanied by young, unmated queens. Queen cells are built in preparation for swarming, and



Unsealed queen cells built on the bottom edge of a comb in preparation for swarming. (Fig. 34)

the first swarm often leaves about the time the cells are sealed (Fig. 34). Swarming is most common in the late spring and early summer periods.

Many factors contribute to swarming. The most readily apparent one is crowding and lack of room for adult worker bees. In experiments on swarming, a colony put into a small hive swarmed in as short a time as 24 hours. Swarming is also associated with the amount and distribution of the glandular secretions of the queen. When there is a shortage of the secretions, the bees make queen cells in preparation for swarming or supersedure. Colonies with queens over a year old are more likely to swarm than those with young queens. The seasonal cycle of colony growth, the weather, and the heredity of the queen are additional factors related to swarming. The colony that becomes big early in the season is more likely to swarm than one that reaches its peak later. Swarming can rarely be prevented entirely but it can be reduced to a reasonable level by good management.

To reduce swarming you must plan ahead to provide your bees with young queens and sufficient hive space at all times. These measures will

reduce but not solve the problem. You must also be able to recognize the signs that indicate a colony is making, or will soon make, preparations to swarm. One evident sign is a mass of bees that entirely fills the hive. They may come out of the hive in large numbers when you open it. A badly crowded colony often has bees clustered on the landing board and on the front of the hive near the entrance. During extremely hot weather such "hanging out" is an attempt to cool the hive and may not be related to crowding inside (Fig. 35). Any crowded colony should be given one or more additional hive bodies filled with combs or foundation. The combs will do them the most good; foundation is of little value unless there is a nectar flow or the hive is being fed so that the bees can complete the comb. It is not unusual for a colony to occupy three or more deep bodies before the main nectar flow begins.

Another warning sign of impending swarming is the condition of the queen-cell cups on the combs. They are always present but are usually short and small. The wax of the cups is the same color as the comb on which the cups are built. As soon as a colony begins preparation for swarming, the cell cups are enlarged, their edges are extended and thinned, and new, white wax can be seen on the cups. The queen will lay an egg in the cup shortly after these preparations. When you find these conditions present, you must try to keep the colony from carrying out its plans. An additional super may solve the problem. If not, you can switch the location of the colony with a weaker one so that many of the stronger colony's returning field bees will be lost to it. You can also remove sealed and emerging brood to add to weaker colonies. If nectar is coming into the hive, add one or more frames of foundation in place of the combs removed.



Worker bees
"hanging out" and
fanning on the
front of their hives
because of the
heat. (Fig. 35)

Prompt action is needed when you find large numbers of queen cells in a crowded colony. Check first to see if the queen is present and, if so, find and destroy all queen cells. Additional hive space may prevent a swarm from leaving, but more drastic measures have a better chance of success. For example, you can divide the colony into two smaller colonies or make one or more nucleus colonies from it. These techniques are explained on page 75. There is little you can do for a colony after a swarm has left except to make sure that it has empty combs in which the new queen can lay.

Excluders

Excluders are used to confine queens to one part of the hive and to prevent them from laying eggs in honey supers. Unless they are kept from doing so by an excluder, many queens make a narrow brood nest up the center of the entire hive. Eventually they are forced down as honey is stored in the upper combs, but there may be brood in the supers when the honey crop is removed. Excluders can save time and effort in beekeeping in spite of persistent claims that they are "honey excluders" that reduce yields. It is true that some strains of bees seem reluctant to pass through an excluder but they may need a period of time to adjust to its presence. Put the excluder and first super on the hive ahead of the nectar flow to allow the bees to become accustomed to passing through it. The benefits of excluders outweigh the disadvantages.

Supering for Honey

As the main nectar flow begins, the colony needs supers in which to store the nectar and the honey made from it. When brought into the hive, nectar is about 50 to 80 percent water. Until it is evaporated and processed into honey, nectar takes up extra comb space. The beekeeper must add supers as they are needed and before the queen's laying is restricted by excess honey in the brood nest. The best way to determine when storage space is needed is to look at the combs and shake them to see how much nectar is being brought into the hive. The incoming nectar stimulates wax production which is seen as new, white wax on the honey cells and along the top bars of the frames.

Change in the weight of a hive is also a good indicator of the need for supers (Fig. 36). Gains of 1 to 10 pounds per day may be recorded during a nectar flow. The colony should be weighed each morning before general flight begins. Otherwise the weight is affected by the number of bees out in the field and by the unprocessed nectar in the hive.



Checking the weight of a colony on a platform scale.
(Fig. 36)

On warm nights the bees process much of the nectar brought in during the day. You can hear the increased activity if you walk through an apiary at night. As soon as a nectar flow begins, the bees in the hive use nectar instead of water and very few continue to visit the regular watering place.

There is no formula to use in deciding how many supers to add at one time. This depends on the strength of the colony and the amount of incoming nectar. It is always best to give too much room rather than too little, especially at the start of the nectar flow. However, if you have only foundation to add, do not put on more than two shallows or one deep super at a time and plan to check the colonies at weekly intervals. The supers of empty comb or foundation can be put on top of the

hive as long as the combs in the super below are not being capped. If they are, you should put the additional supers above the brood nest and beneath the partially filled ones. Top-supering saves time and heavy work while producing the largest possible crop of honey. It also allows you to keep a close check on the bee activity in the supers that were put on last.

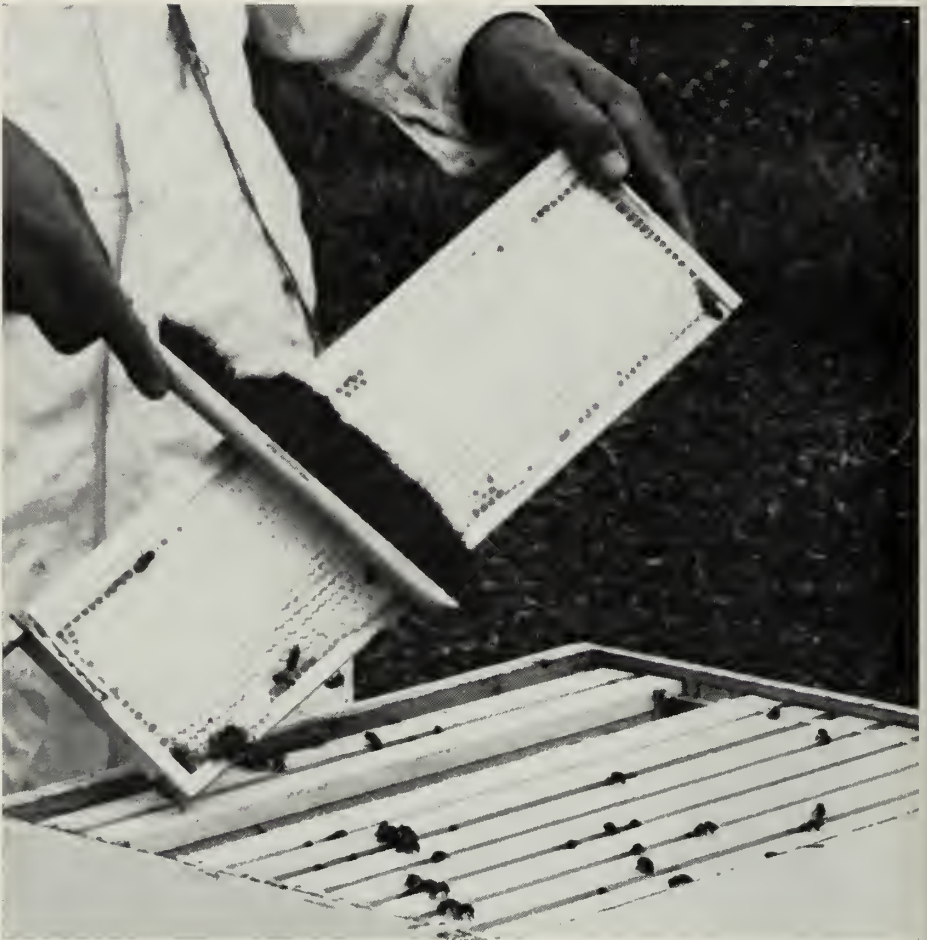
During the heat of the summer, extra supers may be of value to the colony by serving as insulation for the top of the hive. The insulation and the extra storage space can be as effective as shade for increasing honey production.

Removing and Handling the Honey Crop

Surplus honey can be removed from the hive as soon as the cells are completely capped. This timing is essential in producing any type of comb honey because bees will "travel-stain" the cappings as they walk over them. Until honey is sealed, it may contain more than 18 percent moisture and fermentation may occur. Even sealed honey may be high in moisture if the weather is unfavorable for evaporation.

In most areas of Illinois the nectar collected by bees in June and July results in mild-flavored, light-colored honey. This honey is in greater demand when pure than when mixed with smartweed, aster, or goldenrod honey produced in August and September. The main crop should be removed before the middle of August. Leave the partially filled supers and some extra space in case a late nectar flow occurs. At the end of summer the moisture level is usually low enough so that you may remove all the surplus honey. Be sure that the colony has 40 to 60 pounds of honey remaining in the hive for winter.

Bees must be removed from honey combs when the combs are taken out of the hive. This can be done by shaking and brushing, by blowing, or by using bee-escape boards or fume boards with repellent chemicals. For one or two colonies, shaking and brushing is suitable if done quickly to prevent robbing. After smoking the super, give each comb a sharp shake to dislodge the bees into the top of the hive or in front of the entrance. Those bees remaining on the comb can be brushed off with a bee brush (Fig. 37), and the comb placed in a covered empty super. A bee-escape board consists of an inner cover or similar board the size of the top of the hive, with one or more bee escapes mounted in the center or corners of the board. The bee escape is a small metal passage-way with spring closures that allow bees to move through it in one direction only — down into the hive. In use, the board is put beneath the super to be removed. After 24 hours all the bees will have moved



Brushing bees from a frame of sealed honey.

(Fig. 37)

down into the lower hive bodies. Before you put the board on, be sure that there are no holes or cracks to let bees in or out of the super. If there are, robber bees may steal the honey. Do not leave the board on during the day in hot weather or the combs may melt. This system of removing honey is most suitable for use with a few colonies in a home apiary.

Several chemical repellents are effective in driving bees from their honey combs. Carbolic acid, or phenol, has been used for this purpose in the United States since about 1900. It is used on a fume board (acid board), 1 to 2 inches deep, with a black metal cover. The underside of the cover has several layers of cloth to absorb the acid solution. The cloth is sprinkled lightly with a 50-percent solution of pure carbolic

acid before the board is set on the open hive. Smoke the bees just before putting any type of fume board or acid board on a hive. The smoke makes most of the bees begin to move downward into the hive (Fig. 38). The heat of the sun vaporizes the acid and the fumes repel the bees. Carbolic acid is not effective except on warm, sunny days. The acid must be used with caution because it can burn the skin and may contaminate honey if improperly used. Use only enough to lightly dampen the cloth and be careful to keep the pad from touching any comb or hive parts. Have water or a baking-soda solution available in case you get the acid on your skin. With several acid boards in use at one time, you can remove honey supers in a very short time. It is essential that you make sure that bees are driven off the honey but not out of the hive.

Other chemical repellents can be used at lower temperatures and do not require sunshine to be effective. They are used on a slightly different fume board. The cover may be $\frac{1}{2}$ - or $\frac{3}{4}$ -inch-thick pressed board such as Cellotex. The chemical is sprinkled on the underside of the absorbent cover, which is then placed on the open hive after smoking the hive thoroughly. Benzaldehyde, propionic anhydride, and butyric anhydride are used in this way. They are not always effective in repelling bees, apparently because of differences in the way they are applied and the varied reactions of the bees. An overdose may stupefy the bees and some colonies do not respond readily. If you try these chemicals, use a small quantity initially. Increase the dosage if the bees look normal and are not responding. All of the materials must be used with caution and according to the directions on the label. Butyric anhydride has a strong, unpleasant odor that is repellent to humans as well as to bees.

Bee blowers (Fig. 39) are the newest equipment for removing bees from honey combs. They produce a large volume of rapidly moving air that quickly blows the bees out of the combs without injuring them or making them angry. The honey supers are removed from the hive and placed on a stand that is part of the blower. Most models have a chute that directs the bees toward the front of the hive as they leave the super. Blowers are effective regardless of the temperature and the experience of the operator. They may also be used for other routine jobs such as shaking package bees, requeening, and removing extra equipment for moving or wintering. The price of the blowers at present limits their use to commercial beekeeping. However, air compressors and home vacuum cleaners can be used successfully for small numbers of colonies.



Applying a carbolic acid solution to an acid board used to drive bees from honey combs is shown in the top illustration. Placing the acid board on a hive is shown in the bottom picture. The smoke helps to drive the bees from the frames of honey being removed from the hive. (Fig. 38)



A bee blower in use. The super of combs being freed of bees is placed on top of the metal framework. The bees are blown downward toward the front of the hive. (Fig. 39)

Honey that is to be marketed in the comb must be fumigated after being removed from the hive to prevent wax moth larvae from developing in it. Otherwise, these larvae or "wax worms" will tunnel into the comb and make it unsalable. The adult moth lays eggs in cracks and crevices in bee hives in the field but the bees normally destroy the larvae before they do any damage. However, when combs, either empty or full, are stored, the moth larvae develop rapidly and soon ruin the comb by reducing it to a mass of webs and waste material. For details on how to fumigate honey in the comb see page 83. Honey to be extracted need not be fumigated but should be extracted as soon as possible. The empty combs must then be fumigated or replaced on the hives.

Honey is a fine food product and should be treated as such from the time it is taken from the hive until it is in the final container. Honey supers should be handled so that they are protected from dust and dirt as soon as they are freed of bees. One way is to place them on clean, washable wooden pallets or drip trays that can also be used to cover each super or stack of supers. Pallets catch dripping honey, keep dirt and bees away from the combs, and allow the use of a two-wheeled hand truck to move the honey in the apiary and honey house (Fig. 40).

The honey house, or any room in which honey is handled, should be easily cleaned and not accessible to insects, animals, or other possible

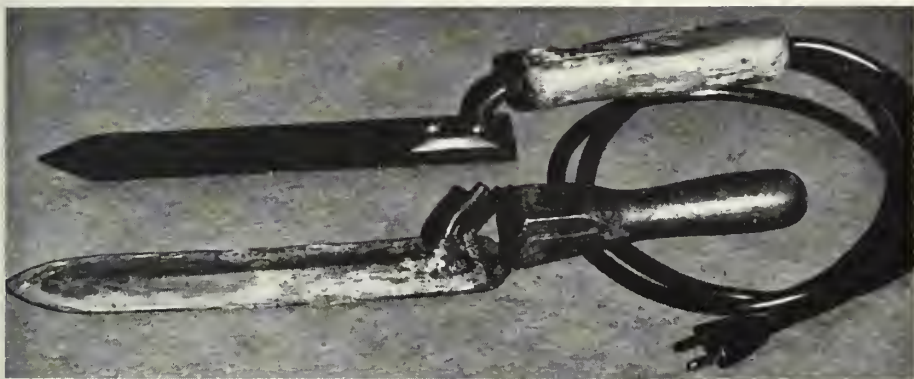


Supers of honey, with pallets on top and bottom, being taken into the honey house on a two-wheeled hand truck.

(Fig. 40)

contaminants such as dust. The beginning beekeeper usually uses the family kitchen and, except for getting honey on everything, has no real problems in sanitation. However, part-time and professional beekeepers producing honey for sale must conform to public health regulations relating to food-processing industries. Before building or remodelling any space to use for handling honey for sale, inquire about the requirements you must meet. For convenience, the honey-extracting area should be on ground level so that you can move honey into it by hand truck either from the apiary or from a truck bed that is level with an unloading area or ramp. Plan your extracting layout to provide a step-saving flow of equipment from the apiary, through the extraction process, and into the comb room. Look at several honey houses before building your own. The apiculture building on the Urbana-Champaign campus of the University of Illinois may provide ideas for your planning.

The first step in removing honey from comb is uncapping — the removal of the wax seals over the cells. This job requires a sharp, heated knife to melt and slice off the cells on each side of the comb (Fig. 41).



Uncapping knives. The one at top is heated electrically and the one at bottom is heated by steam. (Fig. 41)

Commercial beekeepers often remove all the filled comb that projects beyond the edges of the frame. This procedure requires separation of large quantities of honey from the cappings and is not suitable for the beginner. He should remove only a thin layer of cappings and honey. After being uncapped, the comb is placed in an extractor that utilizes centrifugal force to throw the honey out of the cells and onto the side of the extractor. The honey runs to the bottom of the tank where it can be drained.

Extractors vary in capacity from two frames to 72 frames. A two-frame extractor is suitable for a beekeeper with less than 15 or 20 colonies. With more colonies — up to 100 — he needs a four-frame extractor, either hand or power driven. The simplest extractors have a gear-driven basket within a tank. Combs are extracted on one side, and then lifted and reversed to complete the job. Reversible extractors have baskets that pivot to extract either side of a comb without lifting it. Extractors that remove honey from one side of the comb at a time, called tangential extractors, operate very rapidly. However, if turned too rapidly, they may break combs because of the weight of the honey. Extraction of honey in a motor-driven reversible extractor is done in three steps. First, about half the honey is removed from one side of the combs before turning or reversing them. Then the second side is completely extracted. Finally, the comb is turned again and the remaining honey is removed.

The large extractors, holding 20 to 72 frames, are called radial extractors (Fig. 42). Combs are arranged in them like spokes in a wheel with the top bar at the rim. The honey flows from both sides of



Placing an uncapped comb of honey in a 30-frame radial extractor. (Fig. 42)

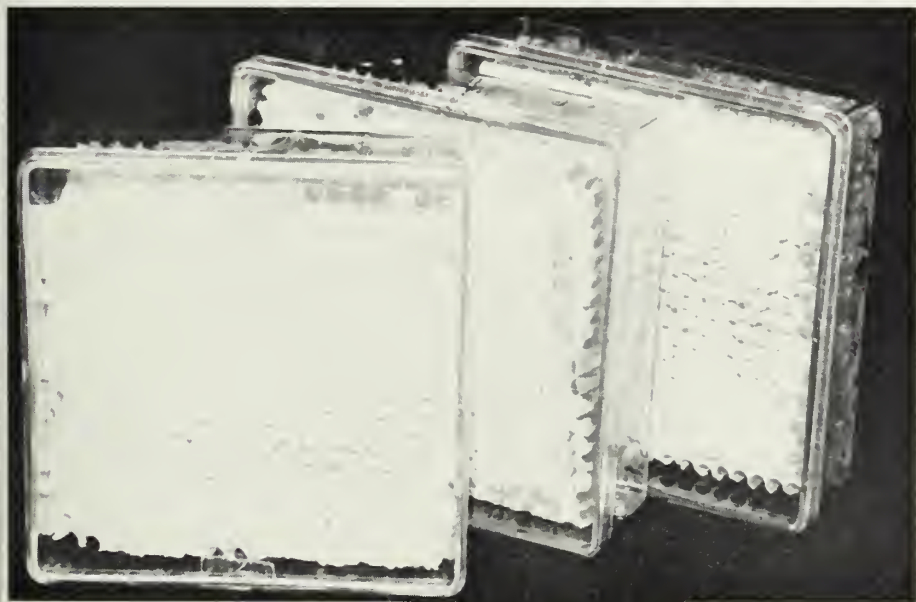
the comb to the walls of the extractor. The natural upward slant of each cell and the centrifugal force make the movement of the honey possible. No reversing is necessary but the extractor must be started slowly and operated for at least 20 minutes to prevent comb damage and remove the honey completely.

After the honey is extracted, it contains air bubbles and bits of wax. Most of these can be removed by a system of baffles and screens in a honey sump into which the honey flows from the extractor. They will also rise to the top of warm honey in a can or tank. The resulting foam can be skimmed off after one or more days depending on the temperature of the honey and the tank size. It is important to remove the wax before final heating and straining. Otherwise it may change the flavor and appearance of the final product. Honey packers generally prefer honey that has been only warmed and coarsely strained or settled. For final packing, honey is heated to 145° for 30 minutes and strained through 90-mesh strainer cloth. The heat liquefies any granules present and thereby retards granulation. It also kills yeasts that can ferment honey, usually after it has granulated. After the jars and cans are filled they should be allowed to cool before being stacked. Commercial honey processors use flash heating and rapid cooling to further prevent

damage to honey by excess heat. Overheated honey is darkened and may even taste burned. Storage temperatures and the length of storage also affect honey quality. Changes in the honey are kept at a reasonable level if it is stored at temperatures of 70° to 75° after processing. Unprocessed honey is best stored below 50°.

Comb honey must be handled carefully to prevent damage to the cappings. After being fumigated, full combs can be readied for sale by scraping the frames to remove propolis, and packaging them in cellophane and cardboard containers. Cut comb honey is cut out of the frames with a thin, sharp knife or with a special heated cutter. The pieces should be allowed to drain in a warm room to remove honey from the open cells on the edges. The pieces can be packaged in foil trays, in cellophane or plastic bags, or in plastic boxes (Fig. 43). Containers, labels, and special equipment of all types are available from beekeeping supply companies.

The composition of honey is variable and complex. Honey from different plant sources are different in composition. The main compounds of honey are sugars that make up 95 percent or more of the solids. The simple sugars (levulose and dextrose) are present in the greatest amount, nearly 70 percent, and levulose is usually predominant. As many as 12 complex sugars including maltose are present in small quantities. Although sucrose (common table sugar) is found in high



Cut comb honey in plastic boxes ready for labeling.

(Fig. 43)

concentrations in nectar, it makes up only 1 to 2 percent of honey on the average. In processing nectar, bees add invertase, an enzyme that splits the sucrose into the simple sugars. Other enzymes in honey are diastase, catalase, and glucose oxidase. There are many acids in honey that contribute to its noticeably acid reaction (pH about 4). The primary acid in honey is gluconic acid, with small quantities of at least 10 other acids present.

Granulation of honey is a natural process of crystallization of some of the sugar from the solution. After granulation, honey can be returned to a liquid form by careful heating of the container with hot water or air. Some honeys granulate very coarsely and may ferment more easily at that time. Finely granulated honey, often called creamed honey or honey spread, can be made easily for home use or for sale. From 5 to 10 percent finely granulated honey is thoroughly mixed at room temperature with liquid honey of 17 to 18 percent moisture. The mixture will granulate smoothly in about a week of storage at 55° to 60°.

The acids of honey react with many metals including steel and zinc used for galvanizing, and may cause damage to processing and storage equipment. For this reason, stainless steel is the most suitable material for such equipment. Piping of stainless steel, glass, or plastic approved for use in food-processing equipment is highly desirable. Galvanized extractors and tanks should be lined with a protective material approved for such use, similar to that used to line honey drums. Many products are available that are used regularly by the beverage and food industries. Most types of paint are not suitable for coating honey equipment and are worse than nothing at all. Some epoxy coatings are also unsuitable because their solvents and other ingredients are not suitable for use in contact with honey.

Marketing the Honey

The beginning beekeeper with a few colonies has no problem in disposing of his honey. He often gives much of it away or, perhaps, sells some to neighbors. As he increases his number of colonies and improves his management, he must decide on how to market the honey. His choices include packing it in jars and cans and selling it to consumers, packing it for sale to stores or to wholesalers, or selling it unprocessed, in 60-pound cans or 55-gallon drums, to individuals or companies who pack it for resale. When the beekeeper sells his honey, he must conform to the requirements of the Illinois food, drug, and cosmetic act that is administered by the Illinois Department of Public

Health. This act corresponds closely to the federal food, drug, and cosmetic act that governs all aspects of food production and labelling in interstate commerce. Copies of the law and general information may be obtained from the Division of Foods and Dairies, Department of Public Health, 130 North Franklin Street, Chicago, Illinois 60606.

The labelling requirements for retail honey containers were revised in 1967. The following summary contains the principal requirements for labelling honey for sale in Illinois and in interstate commerce:

1. The word "honey" must appear in bold type, generally parallel to the base of the container.

2. Honey sold by the producer must bear his name and address, including his postal zip code. Individuals or firms packing or distributing purchased honey must include their name, address (including zip code), and words such as "Distributed by" or "Packed by."

3. Containers holding 1 pound or more but less than 4 pounds must show the weight in both pounds and ounces. For example: Net wt. 16 oz. (1 lb.); Net wt. 32 oz. (2 lb.); or Net wt. 48 oz. (3 lb.).

4. Containers holding less than 1 pound may show weight only in ounces; those holding 4 pounds or more may show weight in pounds only. For example: Net wt. 8 oz.; Net wt. 4 lb.; Net wt. 5 lb.; or Net wt. 10 lb.

5. The net weight must be printed in letters whose size is governed by the area of the principal display side of the container. The area is computed as follows:

Rectangular packages: height \times width of the principal display side.

Cylindrical packages: $\frac{4}{10} \times$ height \times circumference of the package.

Irregularly shaped packages: $\frac{4}{10} \times$ total surface area *or* the entire area of the obvious display panel such as the top of the package.

The minimum type sizes that must be used to show the weight are as follows:

<i>Area of display panel in square inches</i>	<i>Minimum type size</i>
5 or less	$\frac{1}{16}$ inch
Between 5 and 25.	$\frac{1}{8}$ inch
Between 25 and 100	$\frac{3}{16}$ inch
Between 100 and 400.	$\frac{1}{4}$ inch

6. Each type size must have an equal clear space above and below it and a clear space to the left and right of the net-weight declaration twice as wide as the letter "N" in the word "Net."

7. The net-weight statement must be on the bottom 30 percent of panels with an area greater than 5 square inches as computed by the methods given above.

The above information is an interpretation of the labelling law. Copies of the entire law (PL 89-755), the provisions for its enforcement, and additional information may be obtained from the Food and Drug Administration, Department of Health, Education, and Welfare, Washington, D.C. 20201.

Containers for honey should be new and clean. Drums for bulk honey can be reused and should be recoated as needed, but new gaskets are necessary each time the drums are filled. Five-gallon cans should not be reused.

Both comb and extracted honey are sold and purchased by grades established by the United States Department of Agriculture. The standards for grading are not required, but they allow producers and packers to buy and sell a quality product based upon grades established jointly by the honey industry and the Department of Agriculture. The quality of extracted honey is measured by its flavor, its freedom from particles or sediment, its clarity, and its moisture content. Comb honey is graded for many characteristics including the number of uncapped cells, attachment to the section or frame, uniform honey and cappings, and freedom from damage. Copies of *Standards for Grades of Comb Honey and Extracted Honey* are available from the Processed Products Standardization and Inspection Branch, Fruit and Vegetable Division, Consumer and Marketing Service, U.S. Department of Agriculture, Washington, D.C. 20250.

Color is not a factor of quality in the grading system but it is important in the sale and purchase of honey, especially in large lots. Honey colors range from water white to dark amber as measured by two systems. In one, the USDA Permanent Glass Color Standards for Extracted Honey, the color of 2-ounce samples of honey is compared with the color of squares of tinted glass (Fig. 44). In the other,



U.S. Department of Agriculture Permanent Glass Color Standards for Extracted Honey. (Fig. 44)

called the Pfund Color Grader, a wedge-shaped glass trough is filled with honey and matched in color with a colored glass wedge. The matching area on the wedge, measured in millimeters, gives a color rating for the honey sample.

The moisture content, or soluble-solids content, of honey can be measured with a refractometer or a honey hydrometer. Refractometers cost \$100 or more but are essential items of equipment for anyone dealing in large quantities of honey. Only a drop of honey is needed to obtain a direct reading of the moisture content. An attached thermometer indicates any needed temperature correction (Fig. 45). The honey hydrometer is a simple and inexpensive instrument capable of giving an accurate reading when carefully used. It is a weighted glass float that indicates the moisture content of honey by the depth to which it sinks in a warm sample of honey. The readings are corrected for the temperature and converted to percent moisture by using a table that comes with the instrument.

Beekeepers who have a considerable quantity of honey for sale each year should routinely sample each lot of honey as it is extracted or put in containers (Fig. 46). Several samples should be taken from a day's output to get a reasonably accurate representation of the honey. All samples and the cans or drums must be clearly marked to relate them, and a record kept of the number of containers in each lot. A 1- or 2-pound sample will provide enough honey to send small samples to several buyers. If the beekeeper sends samples and knows the color and the moisture content of his honey, he is prepared to bargain for the best possible price for his honey. The U.S. Department of Agriculture provides valuable information about current prices and production in its *Honey Market News*. This publication is available without charge from the Fruit and Vegetable Division, Consumer and Marketing Ser-



Hand refractometer in use for determining the moisture content of extracted honey.

(Fig. 45)



Filling a 60-pound can of honey. The small numbered sample jars can be filled with representative samples of each batch of honey. (Fig. 46)

vice, U.S. Department of Agriculture, Washington, D.C. 20250. The Federal government also operates a price support program for honey that allows beekeepers to borrow money on their crop until they can sell it at the best possible price. If they are unable to sell it above the support price, they may cancel the loan and deliver honey equal to the value of the loan. This program to stabilize honey marketing is carried out through county offices of the Agricultural Stabilization and Conservation Service (ASCS). Local offices in Illinois can provide information about the farm storage loans and purchase agreements for honey.

Beeswax. Beeswax is an important byproduct of beekeeping and a valuable ingredient of cosmetics, candles, polishes, and many specialty items. It is also used in the pure form to make comb foundation. The beekeeper has several sources of beeswax including cappings from honey combs, damaged combs, and the bits and pieces of comb scraped from hive bodies and frames. From 10 to 12 pounds of wax from cappings is obtained for each 1,000 pounds of honey, depending on the comb spacing and yield per colony. An additional $\frac{1}{2}$ to $\frac{3}{4}$ pound per year can be saved from each colony by collecting all the burr combs and scrapings. It is good business to routinely melt very old combs and those with large areas of drone cells, wax-moth damage, and mold. These should be replaced by new frames with foundation to maintain good combs throughout the entire beekeeping operation. A deep super of old combs will yield about $2\frac{1}{2}$ pounds of wax.



Placing a comb in a solar wax melter. The wax pan is removed through the door in the front. A screen across the front of the pan for the combs holds back the slungum while allowing melted wax to run into the lower container. (Fig. 47)

Wax from cappings is light colored and of a high quality, and should not be mixed with darker wax. Cappings should be melted with an excess of water in an aluminum, stainless steel, enameled, tinned, or

galvanized container. Do not use copper or uncoated steel containers because they discolor the wax. Allow the wax to cool slowly, scrape any impurities from the bottom of the cake, and store it until you have enough to sell.

Large numbers of combs can be rendered in a steam chest or a hot water wax press. The combs can also be taken to a beekeeping supply company for rendering. There is a charge for the service based on the amount of wax recovered. The material called slungum, which is the residue left when combs are melted in a solar melter or steam chest, is valuable because it contains up to 30 percent wax. It can be commercially rendered for a fee based on the amount of wax secured from the slungum.

The solar wax extractor is a handy piece of equipment for melting comb, cappings, and other sources of wax. It is a sloping pan within a black, insulated box with a glass top, often of double glass (Fig. 47). The heat of the sun melts wax quickly and it runs into a pan where it can be removed in a cake the next morning. The extractor can be made any size to fit the needs of the beekeeper. However, it should be relatively shallow and large enough to expose several frames or excluders at a time.

FALL AND WINTER MANAGEMENT

The care you give the colony, or colonies, in the fall can be crucial to your success the following year. Because of this, fall management is often considered the starting point in providing strong colonies to produce the next year's honey crop.

Each colony should have enough honey and pollen to last until spring. In Illinois, this means 40 to 60 pounds of honey and as many combs with areas of stored pollen as possible. A well-filled deep hive body with some empty space in the center combs provides enough stores for a strong colony wintered in two hive bodies. It is more difficult to rate the pollen supply, but colonies with a shortage can be given combs from other colonies, or stored combs that contain pollen. Combs can be filled with trapped pollen as explained on page 81. Colonies without sufficient honey should be given full combs saved for the purpose, or fed enough sugar syrup or diluted honey to make at least 40 pounds of stored food.

Bees winter best on combs that have been used for brood rearing. If possible, do not winter bees on all new honey combs, and be sure that any frames of foundation are replaced with drawn comb. Remove the excluder and all empty supers. If you have no other place to store empty combs, you can leave them on the hive above an inner cover with the center hole open. However, it is better to store combs where they cannot be damaged or blown over by the wind. See page 83 for information on fumigating stored combs.

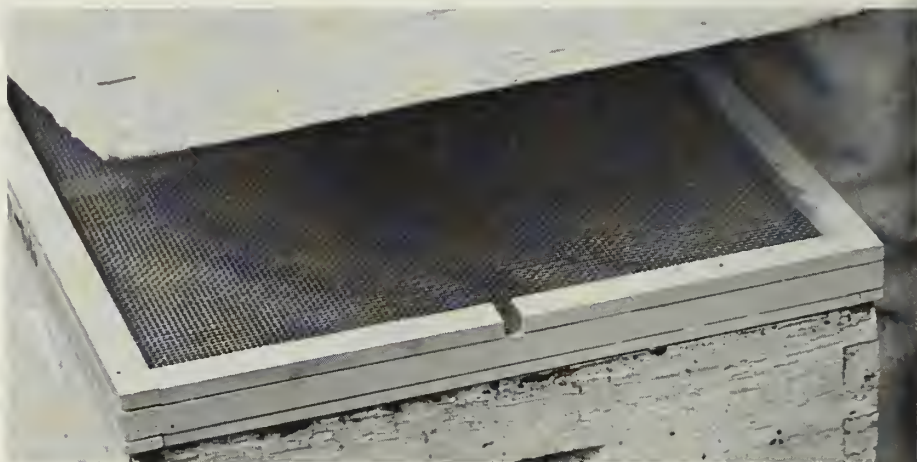
Weak or queenless colonies should be united with stronger colonies that have queens. See page 97 for details on how to unite colonies. Colonies in a single brood chamber do not winter well in Illinois. If you want to keep the individual small colonies rather than unite them, consider putting the small colony above a double division screen on a large colony. A double screen is a wooden frame holding two layers of wire screen, usually 8-mesh. The screens are sufficiently far apart that bees on either side cannot touch. A rim with an entrance cut in one end lets the division screen serve as a bottom for the top colony while the heat from the colony below helps to keep the smaller colony warm. To

use the screen, remove the cover of the larger colony and put the division screen in place with the entrance toward the back of the hive (Fig. 48). Then put the small colony above the screen after making certain that it has a good supply of stored honey of at least five or six full frames.

Good management includes a careful inspection for disease in the fall. If you follow a program of disease prevention with drugs and antibiotics, each colony should be treated after the honey crop has been removed and while the bees are still active. For details see page 104.

As the weather becomes cooler at the end of summer, field mice look for warm places to spend the winter. A nest in the lower corner of a bee hive is just such a place. For this reason it is necessary either to use the $\frac{3}{8}$ -inch entrance or to restrict any deeper entrance used during the summer. An entrance block, a piece of lath with an entrance slot, or a metal entrance reducer can be used. Do not make the entrance less than 4 inches wide or cover it with hardware cloth because the bees that die during the winter may block the entrance. Many beekeepers believe that a small top entrance is essential in winter to provide an outlet for moisture produced by the colony. In experiments at the University of Illinois, Dr. Milum found that colonies without top entrances survived the winter better than those with an upper opening, especially if the bottom entrance was open the full width of the hive.

Cellar wintering of bees and wrapping or packing of hives left out of doors were once common in Illinois. Most bees are now wintered



A double division screen in place on top of a hive. The small entrance is suitable for winter but should be enlarged for use at other times of the year. (Fig. 48)

without any special protection. However, in central and northern Illinois some form of winter packing may still be advantageous to the bees and the beekeeper. Those beekeepers who pack their hives report that these colonies are invariably stronger and in better condition than colonies that are left unprotected. During extended cold periods, a simple wrapping of lightweight black roofing paper may help warm the colony enough to prevent starvation of bees that would otherwise be unable to move to reach additional food. The paper can be stapled, cleated, or tied around the hive and beneath the lid. If you use such a wrap, be sure that the entrance to the hive will not be covered if the paper moves.

Wind protection is important to good wintering. Shrubs, fences, or other artificial windbreaks help the colonies survive by slowing the loss of heat from the hives (Fig. 49). Snow may completely cover the hives without damaging the bees but the hives should not be located where water may collect. The winter apiary site should also be on a slope or in an area where cold air will flow away from the hives and not collect around them. If your winter apiary location does not permit the sun to shine on the hives or is undesirable in other ways for wintering, plan to move the bees to a better location.

Losses of bees during winter are often high in spite of increasing knowledge about the biology and management of honey bees. Many bees of all ages die in the hive. Losses appear to be greater in very



An apiary in winter. The snow fence provides wind protection until the evergreens grow taller. The hives face south and the slight slope allows air drainage. (Fig. 49)

large and very small colonies as compared with those of moderate size. It is not uncommon for more than half of the bees in a colony to die, and for 10 percent or more of the colonies to die. Starvation, either from lack of honey or from inability to reach the honey in extremely cold weather (cold starvation), is the most common cause of winter death of colonies.

MISCELLANEOUS TECHNIQUES IN BEEKEEPING

Confining Bees

Bees can be confined to their hives for short periods to move them, to protect them from pesticides, or to keep them from bothering people or animals nearby. Whatever the method or material used to keep them from leaving the hive, it must be put in place at a time when the bees are not flying, either during the night or in cool or wet weather. The simplest closure is a V-shaped piece of window screen or hardware cloth pushed into the hive entrance (Fig. 50). Any other openings must also be screened or closed at the same time. This method of closing hives is suitable only for very short periods when the weather is not hot. With stronger colonies, or during hot weather, or for longer periods, the colony needs extra space in which to cluster. This can be provided by using an entrance screen and a top screen. These screens have wooden frames that give the bees space in which to cluster outside the hive (Fig. 51). A shallow super with one screened surface makes a good top screen that can be stapled or cleated to the hive.

Bees can also be confined by covering the hives with plastic sheeting, burlap, or other materials. The coverings are draped loosely over the hives and held down by soil around the edges. Black plastic sheeting is suitable for only a short period because it heats up rapidly in the sun. Burlap can be used to keep bees confined for a day or more. In hot weather it can be kept wet to cool the bees beneath it.

Dividing Colonies

Splitting a strong colony of bees into two or more separate units is an important technique in beekeeping. It provides new colonies to replace losses or to increase numbers of colonies. It is also a method of swarm control, and can be used to make up small colonies (nuclei) for rearing or holding queens. To divide a colony you must first find the queen as explained on page 40. If you are unable to find her in a large colony, put a queen excluder between the brood chambers and



Closing a hive with a V-shaped piece of 8-mesh hardware cloth. (Fig. 50)



A hive with top and entrance screens in place for moving. Bees can move into both screens to cluster and to ventilate the hive.

(Fig. 51)

close the hive. Three or more days later examine the colony again. The queen will be in the brood chamber that has combs with eggs. She is easier to find in a single hive body.

Colonies may be divided initially within the same hive by using a double division screen as described on page 71. Place the old queen with about half the combs of brood, mostly unsealed if possible, in the bottom brood chamber. Add an extra hive body with empty combs or combs with some honey if it is needed. Put the double division screen on top of the second body with the entrance facing the rear of the hive. Above it put the second brood chamber containing five or six frames of brood, mostly sealed, and two combs of pollen and honey on each side. This hive body initially should contain about two-thirds of the bees. You may have to shake some extra bees into it from the combs of the bottom chamber (Fig. 52). The older field bees will return to the bottom story leaving the younger bees in the new colony on top. A caged queen should be introduced into the top colony within 2 hours for best results but no later than 24 hours after making the division. After the queen is accepted and laying well, the new colony can be put on a bottom board within the same apiary. Fewer bees will be lost, however, if it is moved at night to a new location 2 or more miles away.

Divisions can be made in the same manner directly into a complete second hive. In this case, give the new colony more than half the bees and four to six frames of sealed brood. The hive may be placed near the parent colony. However, it is better to screen the entrance of the new



Shaking bees from a comb into the hive. One or two sharp shakes remove most of the bees with little antagonism if the bees are smoked first. (Fig. 52)

hive while making up the colony and then to move it to another location at least 2 miles away. Put the screened colony in the shade after you finish the division so that it will not be damaged by overheating. As soon as it is moved to the new location, smoke the entrance and take out the entrance screen.

The same general system of dividing can be used to make small nucleus colonies. For a three-frame nucleus, take one or two frames of brood and bees and a frame of honey from a strong colony. Pick mostly sealed or emerging brood that fills only a third or one-half the frame if possible. Before you put all the combs into the hive, shake one or two additional frames of bees into it. Introduce a queen or a queen cell as soon as possible but not later than 24 hours after making the nucleus. Although the nucleus can be left in the home apiary, it will do better if it is moved to another location.

New colonies of all sizes may be made from brood, bees, and combs from several colonies. Use the same general techniques as explained above and assemble the colony with sufficient bees and stored honey and pollen to get it started. In making divides and nuclei, use small- to medium-sized brood patterns in preference to very large areas of brood. The new colony may not be able to care for a large amount of brood. By using sealed brood, you reduce the number of bees in the parent colony and rapidly increase the number in the new colony.

Feeding Bees

Honey and sugar. More honey bee colonies die from lack of honey than from any other cause. To prevent such losses the beekeeper must know when his colonies need additional food and the best way to give it to them. There are two main periods of the year when feeding is most often needed. The early spring period, after brood rearing begins, is the most critical one. Feeding may also be needed in the fall if the summer nectar flow was a failure or if too much honey was taken from the hive for home use or for sale.

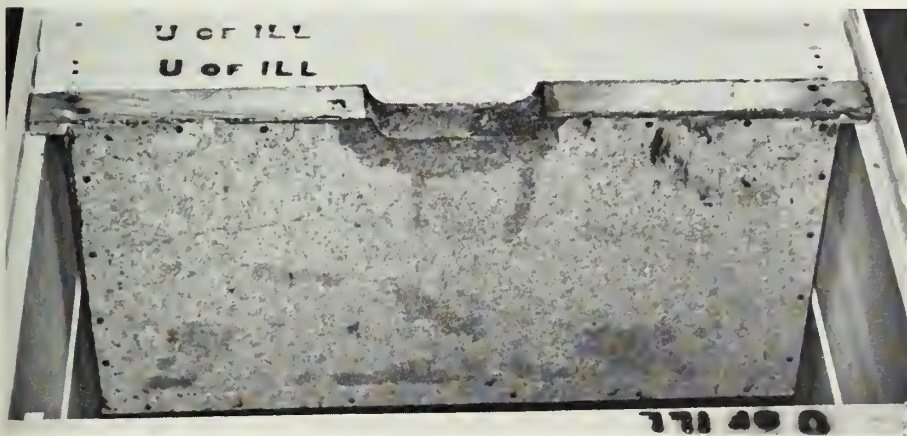
A comb of honey put into the hive beside the brood nest is the simplest feeder. Combs of honey from hives with a surplus can be added to hives short of food, so long as American foulbrood disease is not present. Brush or shake bees from the combs before exchanging them. Extracted honey can be fed to colonies as syrup by diluting it one-fourth to one-half with warm water. Add $\frac{1}{4}$ teaspoonful of sodium sulfathiazole per gallon for disease prevention. For directions and precautions in using drugs see page 104. Honey syrup stimulates robbing in the apiary and should be given to the colonies late in the afternoon

after most flight activity has ceased. Reduce the size of entrances of any weak colonies to minimize the chance of robbing getting started.

Table sugar, either beet or cane, can be used in place of honey to feed bees. For spring feeding, mix it with an equal volume of water to make a light syrup. A heavier syrup of two volumes of sugar to one of hot water is more suitable for fall feeding to provide winter stores. Dry granulated sugar can also be used for feeding. It is put on the bottom board, in an open container in the hive, or on top of an inner cover around the open center hole. The bees must liquefy the sugar to use it and it is not always eaten as readily as sugar syrup. Do not use it for colonies that must have food immediately to survive. Sugar candy or fondant is a convenient form of food for bees if you have the equipment to make it. After being cooked to the proper temperature, it is beaten and then poured into shallow trays that fit the top of a hive. The candy solidifies and is fed to bees by inverting the tray over a hive beneath the cover. Brown sugar, molasses, and other similar materials containing sugar should not be used for feeding bees.

There are several types of equipment and methods used to feed syrup to honey bee colonies. The beginner often uses an entrance feeder that holds a quart jar. It is easy to use but has some disadvantages. For package colonies and other small colonies the syrup in the feeder gets too cold and is too far from the cluster during cool weather. If you use one, put it on the side of the entrance nearest the brood nest and close part of the entrance beside the feeder to reduce the chance of robbing.

The division-board feeder hangs inside the hive in place of a frame (Fig. 53). It holds about 2 quarts and can be refilled without removing



A division-board feeder within a hive body. A wooden float is needed inside the feeder for the bees to stand on when taking syrup. (Fig. 53)

it from the hive. It provides food quickly to strong colonies but is not a good choice for slow, stimulative feeding.

The best all-purpose feeder is the friction top can or similar large containers. Five- and ten-pound honey cans, unused paint cans, and gallon glass or plastic jars can be filled with syrup and inverted above the cluster. The feeder can be set within an empty hive body, either on the frames or over the hole of an inner cover (Fig. 54). Leave part of the inner cover hole exposed so that bees can get out. If the feeder leaks, the bees will collect the syrup and keep it from running outside the hive where it will attract robber bees. For slow feeding and stimulation, punch five to 10 holes in the feeder lid with a threepenny nail. For winter feeding or emergency feeding, use 20 to 30 holes.

There are two emergency methods of feeding to give food quickly to a single colony or to a group of colonies. One method makes use of open tubs or troughs filled with sugar syrup. Corks, wooden racks, or corncobs are added to give the bees a place to land. The tubs are placed in the apiary beneath a temporary cover to protect them from rain. This is a poor method of feeding because the weaker colonies may not



A plastic jar in use as a feeder over an inner cover. An empty hive body and the cover enclose the feeder. (Fig. 54)

get the food they need to survive. Neighboring colonies can also gather the syrup and robbing may become a problem. A better emergency method makes use of combs filled with heavy sugar syrup. To fill them, use a sprinkling can, a coffee can with the bottom full of nail holes, or a garden sprayer free of insecticide residues. Hold the empty combs over a tub or large pan and sprinkle or spray the syrup into the cells of the comb. With both sides filled, a comb will hold several pounds of syrup. Place two or more filled combs next to the cluster of any colony that needs food.

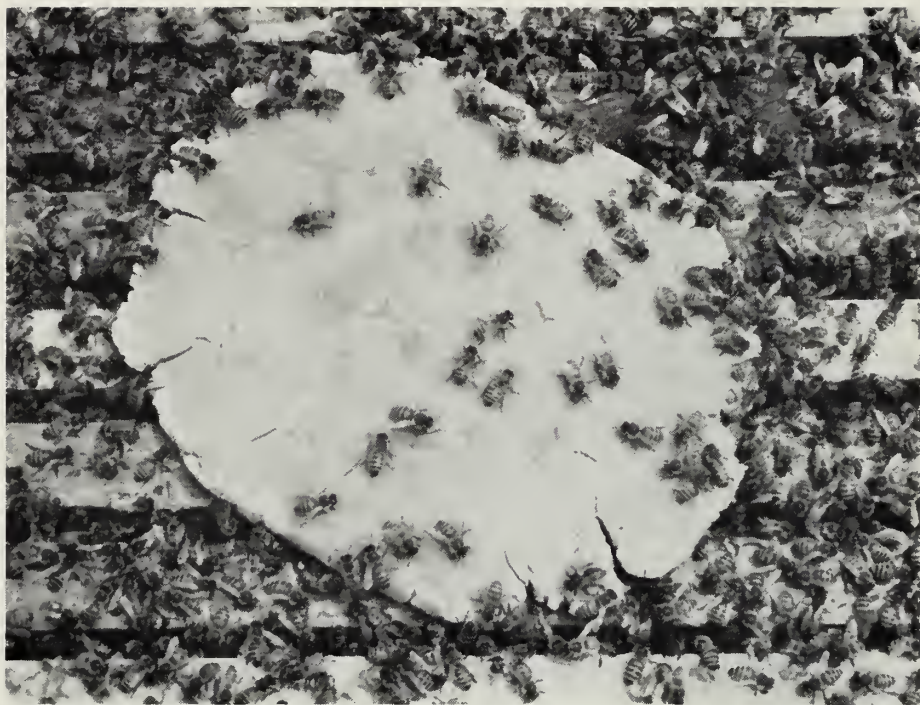
Pollen, pollen supplements, and substitutes. Pollen for feeding bees is obtained by the use of pollen traps that remove fresh pollen pellets from the legs of incoming field bees. (See page 97.) For only a few colonies, combs can be filled with the pellets and used immediately or stored for later use. For larger numbers of colonies this method is impractical. To fill a comb, pour fresh pellets from a pollen trap into the cells on one side of an empty comb, tap the comb several times to settle the pellets, and put it into a strong colony overnight. The bees will pack the pollen into place and the process can be repeated the next day for the other side of the comb. The pellets from the trap also may be dried or frozen for later use.

Pollen substitutes are protein materials, used alone or in mixtures, that bees can use temporarily for rearing brood. Among them are expeller-processed soy flour, brewers' yeast, casein, and dried milk. When the materials are mixed with natural pollen, they are called pollen supplements. They are available from beekeeping supply companies and from feed companies.

The food can be given to bees as a dry mix in open feeders in the apiary or as a moist cake or patty on top of the frames in the hive (Fig. 55). For open feeding, a pan or dish of the mixture can be placed in any open-front box with an overhanging cover to keep out rain and dew (Fig. 56). Large-mesh chicken wire over the opening lets bees in but keeps out other animals.

There are many different formulas for pollen mixtures; they may be purchased ready to use or mixed as follows:

Dry mix:	2 lb. brewers' yeast	
	6 lb. soy flour	
	2 lb. dry, ground pollen pellets, if available	
Pollen cake:	15 lb. soy flour, or soy flour-brewers' yeast mixture	
	5 lb. dried pollen pellets, if available	
	13 lb. water	} sugar syrup
	27 lb. sugar	



Pollen cake in the hive above the brood nest.

(Fig. 55)



Bees visiting a box containing dry pollen mix. The lid is hinged for ease of refilling the pan containing the mixture.

(Fig. 56)

Add enough warm water to the pollen pellets to make a paste. Stir the pollen paste into the sugar syrup and add the soy flour. Knead the mixture into a smooth dough. Add extra water or soy flour if needed. Put $\frac{1}{2}$ to 1 pound of the dough between sheets of waxed paper and flatten to $\frac{1}{4}$ - to $\frac{3}{8}$ -inch thickness. If pollen pellets are not available, use 20 pounds of plain soy flour or a pollen substitute mixture.

Begin feeding the dry mix or pollen cake in February or early March and make it available to the bees continually until natural pollen is available.

Fumigating Stored Combs

Honey combs not protected by a strong colony of bees must be fumigated to prevent damage from the greater wax moth and other moth pests. A beekeeper must assume that any equipment removed from the hives during the active season may be infested. Moth eggs and young larvae are difficult to see. The equipment must be fumigated to kill all stages of the moth (egg, larva, pupa, and adult) and guarded against later infestation as long as it is in storage.

There are many fumigants that kill wax moths including cyanide, methyl bromide, carbon disulphide, sulfur dioxide, paradichlorobenzene (PDB), and ethylene dibromide (EDB). However, all the materials are toxic to humans, some of them extremely so, and they must be used carefully according to the directions on the label and with all necessary precautions. Only paradichlorobenzene (PDB) and ethylene dibromide (EDB) are suitable for the beginning beekeeper. The others should be used only by the commercial beekeeper who has the facilities and experience to use them properly.

Ethylene dibromide is a heavy, clear liquid that is nonflammable and nonexplosive. It forms a heavier-than-air gas that kills all stages of the wax moth including the egg. Equipment to be fumigated should be tightly stacked out of doors or in a well-ventilated room not being used by people during the 24 to 48 hours needed for fumigation. Place 1 to 2 tablespoonfuls of EDB on an absorbent pad beneath the cover of each stack of up to eight full-depth supers of comb. The larger quantity is needed for temperatures below 60°. This material is suitable for combs containing honey as well as empty combs. After fumigation, ventilate the equipment for at least 24 hours before using it.

Paradichlorobenzene is a white crystalline material that vaporizes slowly in air. The gas is heavier than air, nonflammable, and nonexplosive. Place approximately 6 tablespoonfuls (3 ounces) of the crystals on a paper beneath the cover of a stack of not more than five full-depth supers. The supers should be tightly stacked, with any holes and

large cracks covered with tape. PDB kills adult moths and larvae but not the eggs. It also repels moths and should be kept in the stacks at all times for best results. Do not use PDB on combs containing honey because it makes it toxic and inedible. After being treated with PDB, empty combs should be well aired before being used.

If you have only a few supers of stored combs, you should check them regularly during the warm season for any sign of wax moth. For larger amounts of comb, it is better to fumigate routinely at about monthly intervals unless each stack is protected by PDB. Without such precautions you may find one or more stacks of valuable combs reduced to worthless webs and debris.

Hiving Swarms

Swarms are a problem to the beekeeper and to the person who is confronted with them in his yard or some other location. The beginning beekeeper can use them to gain additional colonies or to strengthen established ones. However, the time and expense of obtaining them is often more than the small value of the bees themselves. An experienced beekeeper should consider swarm catching a service and charge accordingly for his time and expenses.

Swarms are not always gentle and you should wear a veil and use a smoker while working with them. Prepare a single-story hive with nine combs, either empty or partially filled with honey. Foundation is less suitable but can be used if you have no empty combs available. If the swarm is close to the ground, or clustered on a branch that can be cut off, smoke the bees and shake them into the open hive or in front of it. In some cases you may have to shake the bees into a pan, burlap bag, or other container in order to carry them to a hive. If you are successful in getting the queen with the rest of the swarm, the bees will enter the hive and make themselves at home. They should be moved that night to a permanent location. The swarm colony can be allowed to develop, or can be used to strengthen another colony. If you know from which colony a swarm came, you may put it back after correcting the conditions that caused swarming to develop.

Swarms sometimes come from colonies infected with American foulbrood disease. The honey carried by the bees can infect the brood of the new colony. This minor danger can be eliminated by hiving all swarms on foundation and immediately feeding them one gallon of sugar syrup containing $\frac{1}{4}$ teaspoon of sodium sulfathiazole. Swarms hived on comb can also be fed in the same way. Whether or not you feed the medicated syrup, carefully inspect the colony for disease at least twice before adding another hive body with combs or foundation.

Identifying Apiaries and Equipment

Hives and apiaries located away from the beekeeper's home should be marked to show ownership. Such identification helps to prevent vandalism and theft because it indicates that someone owns the bees. Otherwise people frequently believe that bees have been abandoned because they do not see anyone visit the apiary. Identification is also essential if beekeepers are to be notified of pesticide applications or other farm operations affecting their colonies.

One form of identification is the owner's name and address stencilled in large letters on the hives or on a prominent sign beside the apiary. The letters should be at least one inch high so that a person who is afraid of the bees can read the sign at a distance.

Frames and other wooden hive parts can be identified by names or symbols stencilled, stamped, or branded on the wood (Fig. 57).



A branding iron and propane torch used to identify frames and other wooden equipment.
(Fig. 57)

Keeping Records

Beekeeping records are of two general types — management and financial. Management records include all the details of the work and observations related to keeping bees. If the information is recorded regularly, it will soon be valuable for planning work, for increasing your knowledge of the biology of honey bees, and for relating manage-

ment to expenses and income. Even a simple diary kept up to date can be a worthwhile and enjoyable part of keeping bees. Some of the things to record are local weather data, dates on which nectar and pollen plants bloom, colony losses, colony weight records, and the dates of doing such jobs as spring inspection, supering, removing honey, and extracting.

Financial records are essential for anyone who keeps enough colonies to sell honey. They should be detailed enough to make a financial summary each year for your own information and for computing income taxes and other reports required for business. The Farm Record Book available for \$1 from the Office of Publications, 123 Mumford Hall, Urbana, Illinois 61801, can be modified for keeping detailed records of a beekeeping business. An apiary record booklet (ID 29) is available for 42 cents from the Mailing Room, AES Building, Purdue University, West Lafayette, Indiana 47906. It includes space for labor records, cash expenses and receipts, inventory, and summaries of the year's records.

Bank-operated record-keeping services can be adapted for beekeeping enterprises as well as for farm businesses. They simplify record keeping for tax purposes and may prove helpful in making short- or long-term loans. Lending institutions need net worth statements and cash flow records in support of loan applications.

Killing Bees

Honey bee colonies should be killed when they become infected with American foulbrood disease, when they are living in the walls of a building or some other unsuitable location, or when bee equipment must be freed quickly of all bees. Any material used to kill a colony in a hive must have no residual effect that would prevent reuse of the combs or wooden parts. Insecticides cannot be used for this reason. Although it is highly toxic, the best material to use is powdered calcium cyanide, sold as Cyanogas A-Dust. In contact with water or moisture from the air it releases cyanide gas. **The material is extremely dangerous** and must be used only outdoors and with proper precautions to avoid breathing the gas or dust. When not in use, it should be kept in a locked, dry place.

Kill the bees in a hive when they are not flying, either in the evening or early morning. Sprinkle a tablespoonful of the dust on a piece of paper or cardboard several inches square and slip it into the hive entrance. If you are dealing with a strong colony, be sure to spread the dust over a rather large area. The dying bees will sometimes cover

a small pile of dust and prevent it from vaporizing properly. Close the entrance and leave the hive alone for at least 30 minutes to allow the gas to dissipate.

Colonies in buildings should be killed only with insecticides such as carbaryl (Sevin), malathion, or chlordane. Fumigants, such as cyanide gas, are too dangerous for this purpose. It is important to first locate the brood nest in the wall to learn whether it can be reached by insecticide sprayed or dusted into the flight hole. Sometimes the brood nest is a long distance from the entrance. By tapping and listening you can locate the main group of bees on a cold day or at night when the bees are not flying. Apply the dust or spray at the entrance or through a hole drilled close to the brood nest. Use the material at the concentration recommended on the label for control of garden insects, wasps, and ants. After the bees have been killed, the dead bees and comb should be removed from the wall and burned or buried. The location will be attractive to other swarms unless all the holes and cracks are sealed shut.

Moving Bees

Illinois beekeeping is gradually becoming more migratory as more colonies are moved to sources of nectar and are used for pollination. Even those beekeepers who don't regularly move their hives must sometimes move them short or long distances.

The field bees from hives moved short distances — a few feet to as much as a mile or more — tend to return to the original hive location. As they fly out into familiar territory they use the landmarks and flight paths that bring them back to the old hive location. If one hive of a group is moved a short distance, its returning field bees will join hives beside the old location. It is better, if possible, to move all the hives together, a few yards at a time, when relocating them a short distance. Move the bees in the evening or early morning after thoroughly smoking the entrance and any other openings. You may leave the entrance open or screen it closed with a folded piece of window screen or 8-mesh hardware cloth. (See Figure 50.) Careful handling usually makes it unnecessary to fasten the hive parts together to move colonies within an apiary or close to it. However, if you want to fasten them together, do so at least 4 hours before moving the bees.

Most bee moving involves distances great enough to put the field bees into territory unfamiliar to them. No exact minimum distance can be given because it varies with each area and with the foraging distances of the field bees. In some areas a 1-mile move is sufficient,

but a good average distance is 2 miles. Naturally, the farther you move the bees the less likely is the chance that some foragers will return to the old location.

The best time to move colonies is about dusk when most of the bees are no longer flying. Early morning is less suitable because the increasing light intensity and rising temperature make the bees eager to leave the hive. If you have difficulties, it is better to have the extra time available at night. A cool, rainy day is also a good time to move bees at any hour so long as the bees are not flying.

The beginning beekeeper who moves bees by truck or trailer should make preparations to complete the job without accidents. Prepare the colonies a day or more ahead of the move by fastening the hive parts together. Use hive staples, lath, or steel or plastic strapping. If you use staples don't put more than four between any two hive parts. Drive them in so they make an angle of about 45 degrees with the



Hive staples in place to hold hive parts together for moving.

(Fig. 58)

crack where the hive parts meet (Fig. 58). Lath cleats are placed on opposite sides of the colony and nailed in place with two or more three-penny or fourpenny nails in each hive part. Be sure to smoke the hive well before you hit it with the hammer. Steel strapping is easy to use and holds the hives tightly but it requires special, fairly expensive equipment. Plastic tapes are equally good and are easier to fasten with simple equipment. In hot weather, especially with strong colonies, moving screens should be used in place of the regular hive cover. Cover an empty shallow super or similar wooden frame with window screen or 8-mesh hardware cloth and place it, screen side up, over the hive. (See Figure 51.) The bees can cluster in the space and ventilate the colony through the screen. Fasten the hive together with the screen in place. Cut an entrance screen for each hive the exact length of the entrance and about 4 inches wide. Fold it into a loose V that will slip into the entrance and stay in place. Seal or plug all other holes in the hive.

When you are ready to load the hives, put on a veil and light a smoker. Smoke the hive entrance well and wait a minute or two before slipping in the entrance screens. If bees are clustered on the front of the hive you may have to smoke them more than once and wait several minutes before they all go into the hive. Place the hives in a truck or trailer with the entrances facing forward. Arrange the hives as close together as possible in order to reduce bouncing and shifting while enroute and tie them in place if possible. At the new location put all the hives in place, smoke the entrances well, and remove the entrance screens immediately. You may remove the top screens at this time or leave them in place with a cover over them until you have time to remove them.

The advanced amateur or the commercial beekeeper usually moves bees without entrance or top screens except on occasions when special precautions are needed. Hives moved regularly should have the bottom boards nailed in place and should be equipped with covers that are the same width as the hive bodies. Proper hive equipment and a flat-bed truck with hooks on which to tie the ropes reduce problems in moving bees (Fig. 59). A typical move by a commercial beekeeper may take place as follows. At dusk he drives into the bee yard and prepares to load the hives onto the truck with its headlights off but with the running lights on and engine running. The running lights give him some light to see by without attracting bees, and the vibration of the engine helps to calm the bees after they are loaded onto the truck. With the help of another man, or with a hive loader, he quickly places



Moving bees with
an electric hive
loader. (Fig. 59)



Cradle of hive loader
with control buttons.
Spring-loaded clamps fit
into the hive handholds
to support the hive.
(Fig. 60)

the hives, one to three tiers deep, in rows of five across the truck. He smokes each colony before loading it and periodically smokes the bees on the truck if they show signs of unrest. As soon as the load is in place, he ties each row using a trucker's hitch and a good quality $\frac{3}{8}$ -inch hemp or polypropylene rope. At the new location he turns off his headlights, leaves the engine running, and lights a smoker. After smoking the entire load, he unties the ropes and unloads the hives. He is ready to leave the apiary as soon as his smoker is out and the ropes coiled.

Hive loaders make bee moving a one-man task. They are also useful for handling honey supers and other equipment. (See Figures 59 and 60.) Heavy-duty loaders can handle two hives on a pallet or one above the other for loading two tiers at a time. A tractor with a fork lift can be used for loading pallets with six or more hives. Such palletized hives are preferred by apple growers in Illinois for use in hilly orchards where a tractor must move the bees to their locations among the trees. The hives are strapped to the pallets and tied with ropes to the truck.

A permit is required to move colonies of honey bees or used equipment between counties in Illinois. Before issuing the permit, an apiary inspector must have inspected the bees within 60 days of the date the bees are to be moved. For inspection and permits contact the Apiary Division, Illinois Department of Agriculture, Springfield, Illinois 62705.

Queen Bees

The queen is all-important to the colony, and the techniques of handling and introducing queens are important to success in beekeeping. After learning to find the queen and to evaluate her quality, you must learn to handle her and replace her if necessary.

The best way to pick up a queen is to grasp both pairs of wings between your thumb and forefinger without pressing her body, especially her abdomen. After getting her up off the comb, hold her against the forefinger of the other hand and trap at least two of her legs with your thumb. Release her wings and you are ready to mark the queen or clip her wings (Fig. 61). Before handling a queen, you can practice the technique on drones. Virgin queens may sting occasionally but a laying queen will almost never do so.

Queens are clipped by cutting across one pair of wings to remove about one third of the longer wing. A fine pair of scissors such as manicure scissors can be used. Clipping once was considered to be a method of swarm control because the first swarm came back when



Holding a queen bee in preparation for marking her. Her legs are held gently but firmly between the thumb and forefinger.

(Fig. 61)

the queen was unable to fly. Now the only reason to clip a queen's wings is to indicate her age. If you wish to do this, clip the left wing in odd years, right wing in even years. Clipping, however, may lead to supersedure of the queen.

Queens are marked to make them easier to find in the hive and to indicate their age. Queens of the dark-colored races (Caucasian and Carniolan) should always be marked because they are more difficult to find than Italian queens. Hot-fuel-proof model airplane dope is a satisfactory marking material that comes in a wide range of inexpensive, bright colors. Apply a dot of the dope to the queen's thorax, being careful not to get it on her antennae, wings, or membranes. You can practice on drones before attempting to mark a queen. Use a fine brush or, better, a round-headed pin stuck in a cork. Hold the queen briefly after marking her to let the mark dry, and then release her on a comb. In Europe an international marking system of five colors is used to relate the queen's age to her marking. The colors and years represented are as follows: 1968 — red; 1969 — green; 1970 — blue; 1971 — white; 1972 — yellow; 1973 on — repeat sequence of colors. A German bee-supply company, listed in the section on equipment dealers, sells queen-marking sets with numbered plastic disks in the five different colors. They are of value if you wish to identify each queen individually. The company also sells marking tubes that can be used to hold worker bees for marking. (See Figure 62 for examples.)

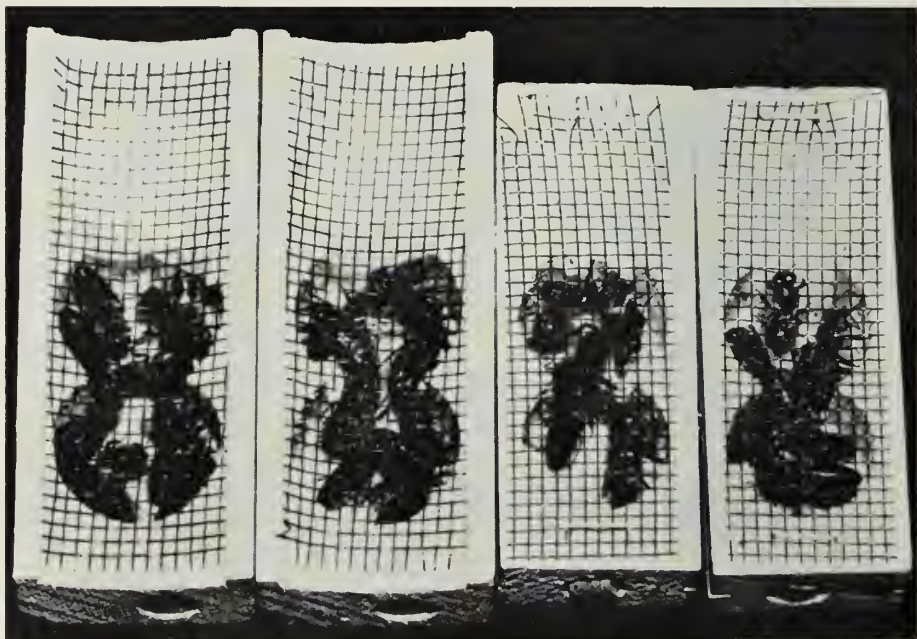


Bee-marking equipment. Marking disks, in five colors, are used on queens or workers. Worker bees held in the tube are marked through the netting. Model airplane dope in the vials is applied with the head of a pin stuck in the cork. (Fig. 62)

Queen introduction is an important part of bee management. A new queen introduced into a mean colony can change its temper in a few weeks and a young queen can more than pay for herself by the increased honey production of her colony. Poor queens should be replaced whenever they are found, and most colonies should be re-queened every 2 years.

The first step in replacing a queen is to obtain a young, mated queen from a bee breeder. The queen, together with six to 12 attendant bees and a supply of queen-cage candy for food, will arrive in a small wooden cage with a screen top (Fig. 63). Give the bees a few drops of water on the screen as soon as the cage arrives. If you cannot introduce the queen that day, give the bees water twice a day and keep them in a warm place out of the sun. There are holes in each end of the cage that are covered with cork, cardboard, or a piece of metal. In preparation for introducing the queen, remove the cover from the hole on the candy end to expose the candy.

The next step in introduction is to make certain that the colony that is to receive the queen is queenless and without queen cells. Remove and kill the old queen, if there is one, and crush all queen cells with a hive tool to kill the larvae in them. Within 2 hours, place the new, caged queen in the hive. Before that, however, the attendant bees (workers) in the queen cage should be removed. Many queens are



Queens and attendants in two types of queen cages. One compartment is filled with candy that serves as food for the bees when they are shipped by mail. (Fig. 63)

introduced with the attendants present but, because the colony may be antagonistic towards them, the queen will have a better chance of introduction by herself. Remove the cork and let the bees and queen out on a window of a room in which the lights have been turned off. They will buzz and fan their wings but will rarely sting. As soon as they are all out, pick up the queen and put her, head first, into the hole in the cage. If you don't want to pick her up, hold the cage close to the queen and "herd" her into it with your fingers. She is then ready to be introduced to the colony just prepared. Wedge the cage, candy end up, between the top bars of two frames in the center of the brood nest (Fig. 64). Close the hive and do not disturb it for at least a week.

There are several other types of queen-introducing cages (Fig. 65). One of the most useful is the push-in cage, made of either metal or cardboard. Both kinds work on the same principle, but the metal cage requires the addition of queen-cage candy. Shake the bees off a comb of emerging brood from a colony ready for a new queen. Place the queen beneath the cage on an area with a few cells of honey and emerging bees. Press the cage at least $\frac{1}{8}$ inch into the comb. Replace the comb in the brood nest and leave the hive alone for at least a week.



Introducing a caged queen between the combs of a queenless colony. (Fig. 64)



Old and new types of queen-introducing cages. Included are a wooden mailing cage shown at top center, a metal push-in cage at right center, and paper push-in cages at bottom left and right. (Fig. 65)

The queen will be released when the bees eat the queen-cage candy in the tube or tear the cardboard cage to pieces.

Queens are most readily accepted by colonies during a nectar flow. At other times you can improve your chances of success in introduction by feeding the colony a light syrup for several days before and after putting the new queen in the hive.

Queen rearing is one of the most fascinating parts of beekeeping but is beyond the scope of this circular. When you have mastered keeping bees for honey production, try queen rearing. Books on the subject are available at libraries and from beekeeping supply companies.

Repelling Bees

When robbing gets started in an apiary, it may be necessary to repel robber bees from weak colonies, open hives, and any equipment stacked in the apiary. The first thing to do is reduce the size of entrances of all weak colonies or nuclei. Stuff grass, leaves, or similar materials into the entrance so that only a small open area is left to be defended by the bees. To make it easier for the bees to remove the material later, do not push it in too tightly. If you must continue to work, expose as little of the hive as possible. Use the cover, excluder, and wet cloths if necessary to keep bees from entering the supers. A very weak solution of carbolic acid (phenol), just strong enough to smell, can be used to wet the cloths or to sprinkle on the outside of hives or empty equipment that bees are attempting to enter.

There are no effective repellents available for use on crop plants to reduce insecticide damage to bees. It is also difficult to repel bees from their accustomed watering places such as bird baths and other places where they are not wanted. The mandibular gland secretion of honey bees acts as a repellent to other bees. Research on this secretion may lead to discovery of materials that will keep bees out of places where they are not wanted.

Transferring Bees

Many publications have been written about transferring bees from primitive hives, buildings, and trees to modern hives. They usually suggest tearing open the colony and fitting the combs into new frames. Another method uses a screen cone or bee escape over the flight hole so that bees can come out but not reenter the hole. The displaced bees are supposed to enter a hive located beside the entrance.

Transferring bees is no job for the beginning beekeeper, and it is not worthwhile for the experienced one who can obtain all the bees

he needs by dividing his colonies. Rather than risk the possibility of being seriously stung for little reward, you should resist the temptation to transfer a colony and, instead, should kill the bees or leave them alone. If you want to try removing bees from a building, do the job for a fee, not just for the bees and any honey in the colony. You might consider transferring bees as a sport or a form of recreation, but it is not a good way to begin beekeeping or to increase your number of colonies.

Trapping Pollen

Trapped pollen is of value for feeding bees. It will become increasingly important in Illinois as our natural sources of pollen become scarcer and as we use more colonies for spring pollination, such as for apples. A market may develop for pollen for use by commercial beekeepers to feed their colonies.

Pollen traps vary in some features of design but all of the available models have a double screen of 5-mesh hardware cloth that scrapes some of the pollen pellets from the legs of incoming pollen-collecting bees (Fig. 66). The pollen falls through another screen into a box or tray where it is inaccessible to the colony and can be removed without disturbing the bees. The traps remove only part of the incoming pollen and they stimulate colonies to collect more. They probably reduce honey production if used on the same colony for more than a week or two at a time. However, the value of the pollen for supplemental feeding can easily offset the loss of part of the honey crop from a few colonies.

The pollen should be collected from the traps at least three times per week and dried or frozen for storage. If you wish to dry the pollen, use shallow layers exposed to the air or heated at moderate temperatures (not over 140°) in an oven. Ants, wax-moth larvae, and small beetles are often found in the pollen. The ants can be discouraged by use of sticky barriers or pans of oil surrounding the supports for the hive (Fig. 66). Rain ruins pollen quickly and all traps seem to be vulnerable to it. In selecting a pollen trap, choose the design that will best keep rain out and provide the maximum area of ventilation for the hive.

Uniting Bees

Weak colonies are often liabilities instead of assets. This is especially true when they have poor queens or have been queenless so long that laying workers are present. Such colonies will not make any honey and are not good risks for wintering. They should be united with a



Pollen trap and stand that fit beneath the hive. Bees enter through the wide entrance and crawl upward into the hive through the double screen. The pollen falls through the bottom screen and is removed on a tray from the rear of the hive. (Modified from an original design by the Ontario Agricultural College in Canada.) (Fig. 66)

moderately strong colony with a good queen. Uniting two weak colonies will not produce one strong colony.

Kill any queen present in the weak colony and place the hive, without a bottom board, above a single sheet of newspaper over the open top of the stronger colony (Fig. 67). Punch a few small slits in the paper to make it easier for the bees to remove it. In hot weather wait



Uniting a small colony with a larger one by the paper method. (Fig. 67)

until late afternoon so the heat and lack of ventilation will not damage the upper colony. The bees will remove the paper with little fighting and the colonies will be united. Any colonies united in the fall should be checked again before winter to be sure that the clusters are together and that the hive has sufficient stores for winter.

Although the newspaper method is the safest way to unite bees and causes few losses of bees, colonies may be united without the precau-

tions mentioned above. You can unite bees from several hives in the same way as you can make divides and nuclei from frames of brood and bees from several colonies. If none of the queens are of special value, put all the bees together without finding or killing any queens. The youngest queen is most likely to survive and only rarely will all of the queens be killed. The united colony should be checked after a week or two for the presence of the queen and its general condition and arrangement. When colonies are united, the returning field bees from the relocated hives are disoriented for a few days. They soon join other colonies in the vicinity of their original hive and settle down with only minor fighting.

DISEASES, PESTS, AND PESTICIDES AFFECTING HONEY BEES

The honey bee is subject to many diseases and pests as are other insects and livestock. The diseases differ in their severity but all of them can be prevented or controlled by proper management. Such management includes knowing and recognizing the symptoms of diseases, inspecting colonies regularly, and applying control measures promptly when disease is found. Drugs and antibiotics are effective in preventing disease but cannot substitute for good management. They must be used at the proper time and dosage to avoid contamination of honey.

The diseases of bees are usually divided into two classes — those that attack the developing stages (the brood), and those that attack adult bees. In general, the brood diseases are more serious and their symptoms are more definite and distinctive than those of the adult diseases. It takes experience and close observation to distinguish a diseased larva or pupa from a healthy one, or one dead from other causes. This experience can be gained only by frequent examination of the combs of a colony. This is one of the reasons why the beginning beekeeper must open his colonies regularly.

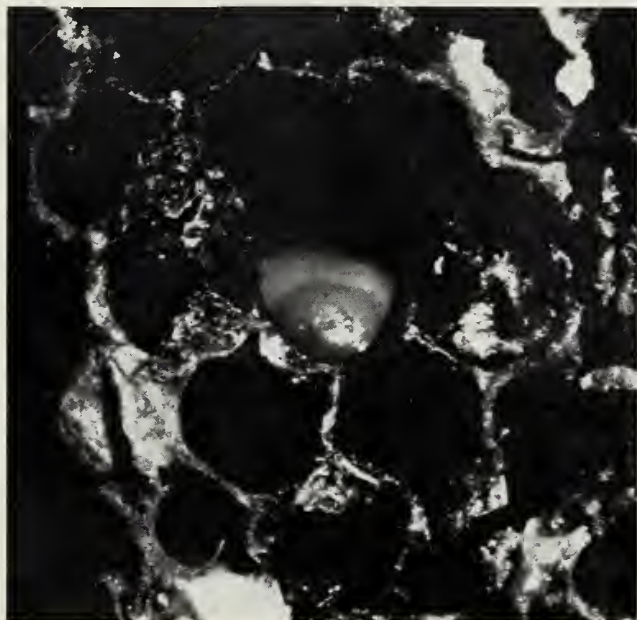
Brood Diseases

American foulbrood. This disease, usually called AFB, has always been a problem in beekeeping. It is caused by a bacterium, or germ, called *Bacillus larvae*, which has a long-lived, resistant spore that can remain dormant for more than 50 years in combs and honey. When food containing spores is fed to a young larva, the spores germinate and multiply until they kill the developing bee just after its cell is sealed. Until that time no symptoms of the infection are visible except perhaps a slight graying or dullness of the usually glistening white immature insect. The infected bee dies as a larva stretched lengthwise in the cell, or as a new pupa with the body features of an adult bee. The capping of an infected cell may be slightly sunken and darker than healthy ones around it. Adult bees often puncture the cappings of infected cells and may remove them entirely. Since there are also holes

in cells containing healthy larvae being capped, you must learn to distinguish them from abnormal ones. Worker, drone, and queen larvae and pupae are all susceptible to American foulbrood.

The larva or pupa that dies of AFB always lies perfectly straight on the lower side of the cell (Fig. 68). It loses its pearly white color and rapidly turns light brown similar to the color of coffee with cream. As it continues to decay and become dried, it turns dark brown and, finally, it turns into a black dried scale on the lower side of the cell. Other characteristic symptoms of American foulbrood are the somewhat glossy, uniform color of the dead larva or pupa, and the melted look as the body and the body wall rot. Sometimes the bacteria make the pupal tongue stick to the top of the cell. When this happens, the tongue looks like a smooth, fine thread extending vertically across the cell. However, many advanced cases of American foulbrood do not show this symptom.

The bacteria rot the skin of the developing bee and turn the body into a slimy mass that becomes stickier as it dries. This condition is the basis for the "ropiness" test that can be used to aid in diagnosing the disease. When making a diagnosis, *do not touch the suspected cell*, other than to remove the capping, until you have carefully examined its color, position, and other features. Only then should you touch the dead remains with a straw, toothpick, or match stick. Do not use a hive



A dead larva infected with American foulbrood shown head on. It shows the typical melted appearance, even color, and straight position in the cell. The cell walls and cappings were broken to expose the larva.

(Fig. 68)

tool for this purpose. Watch to see what happens when you poke the remains. The larva or pupa with AFB will often collapse into a rubbery mass. Stir it with the stick and withdraw it slowly. If it strings or "ropes" out, see how far it will pull out. More important however, is what happens when the string breaks. If the cell is infected with American foulbrood, the mass on the stick should look like a drop with no sign of the drawn-out string. The remains left in the cell should be smooth with no sign of the drawn-out piece. In contrast, a cell infected with European foulbrood usually strings out and breaks off like a piece of dough or taffy.

The odor of American foulbrood is distinctive but *is not* a reliable indicator because people's sensitivities to odors vary so widely, and the odor may be strong or weak. The odor is similar to that of old-fashioned animal glues that are now rarely used. However, it is better to rely on your eyes to diagnose the disease.

The black scales of cells infected with American foulbrood, blend in color with dark combs and are difficult to recognize. To see them, hold the comb so that sunlight strikes the lower side of the cells. The faint outline of the scale and the slightly raised head portion of it will be evident in infected cells. When examining combs of dead colonies, look for any sign of scales. They may be the only disease symptom present in the hive.

American foulbrood is spread by the exchange of infected honey and combs between colonies, either by the beekeeper or by robber bees. Infected colonies rarely recover and as they become weakened and die, they are often robbed by bees from nearby colonies. Reduce the size of the entrance of any weak colony, and close any dead colony and remove it from the apiary. You must be certain that weak or dead colonies do not have AFB before you exchange any combs or honey from them or unite them with other colonies.

If you need help in inspecting your colonies or diagnosing disease, it is available without charge from the Apiary Division, Department of Agriculture, Springfield, Illinois 62705. The best time for inspection is the period from mid-March to about June 1st, before the nectar flow begins. Samples of diseased comb for laboratory examination can be sent to the Bee Pathology Laboratory, Entomology Building A, Agricultural Research Center, U.S. Department of Agriculture, Beltsville, Maryland 20705. They may also be sent to the Extension Apiculturist, Department of Horticulture, 107B Horticulture Field Laboratory, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. Select a sample of brood comb about 5 inches square that contains large num-

bers of affected cells. Mail it in a strong cardboard or wooden box *without* an airtight wrapping. Samples that are crushed or moldy because of improper packing make diagnosis impossible.

Illinois state law requires the burning of colonies of bees infected with American foulbrood. The colony must be killed and all the contents of the hive burned, including bees, combs, frames, and honey. (See page 86 for directions for killing bees.) The fire should be built in a pit and the ashes covered afterwards. The cover, bottom board, and hive bodies should be scraped and then scorched. A blowtorch or weed burner is suitable for scorching small quantities of equipment. For large quantities, brush the inside surfaces with a mixture of one-half gasoline and one-half motor oil and stack the hive bodies four or five high. Light the stacks and allow them to burn long enough to lightly char the wood. Place a cover over the stack to put out the fire. Afterward, separate the hive bodies and be sure that all the fire is out or it may later burn up the equipment.

Many methods of saving and treating diseased colonies have been tried and found to be ineffective. These methods sometimes require more expense and labor than the value of the diseased colonies. When not done properly, the treatments often spread disease. Inspection and prevention are the best methods of control. The two medicinal agents that are valuable for preventive feeding for American foulbrood are sodium sulfathiazole and oxytetracycline HCl (Terramycin). Neither material kills the disease organism but they prevent its growth when they are present in the food fed to larvae.

Sulfathiazole is a stable material suitable for use in sugar syrup or honey. Use $\frac{1}{4}$ teaspoon per gallon of feed. Higher dosages may be toxic to the bees and are no more effective in controlling the disease. Sulfathiazole powder mixed with an equal volume of powdered sugar can be used at the rate of $\frac{1}{2}$ teaspoon per colony and placed on one or two top bars in the brood nest.

Terramycin is relatively unstable in honey or syrup solutions and is best used as a dust in mixture with powdered sugar. It is available in two forms — Terramycin Animal Formula Soluble Powder (TAF-25) containing 25 grams active material per pound, and Terramycin Feed Premix (TM-10), containing 10 grams active material per pound. The second formula is less expensive per gram of Terramycin. For each colony, dust 3 tablespoonfuls of the dust mixture over the top of the frames at the outer edges of the brood nest. Mix the dust as follows: 1 lb. TM-10 to 3 lb. powdered sugar; or $\frac{1}{2}$ lb. TAF-25 to 4 lb. powdered sugar. The material is somewhat toxic to bees and should not

be used at higher dosage levels. Reduce the amount of Terramycin for weak colonies.

Mixtures containing both Terramycin and sodium sulfathiazole are being used effectively for disease prevention by commercial beekeepers. The following formula is one such mix:

- 8 parts by wt. trace-mineral salt, finely ground;
- 8 parts by wt. confectioners sugar;
- 4 parts by wt. TM-10;
- 1 part by wt. sodium sulfathiazole.

The ingredients are thoroughly mixed and applied by putting 2 heaping teaspoonfuls in piles on the frame tops at the back of the brood chamber two or three times a year.

Any medicinal agents or mixtures should be applied only after inspection in the spring at least 2 months before the main nectar flow. They may be used again after the honey is removed in late summer or during the fall. Use them with care at the proper dosages, and follow the directions and precautions on the labels. The products are available at beekeeping supply companies, livestock supply stores, and feed stores.

European foulbrood. This brood disease, usually called EFB, appears to be much less common than American foulbrood in Illinois. It is caused by a bacterium, *Streptococcus pluton*, that does not always kill the infected larva but sometimes may kill large numbers of larvae very rapidly. The disease and its symptoms are highly variable, probably because of the presence of several other organisms in the dead and dying larvae. EFB does not usually kill the colony, but a heavy infection will seriously reduce honey production. It is not necessary for beekeepers to kill colonies infected with EFB, but it is essential to be able to distinguish European from American foulbrood disease.

Larvae infected with EFB usually die while still coiled in the bottom of the unsealed cell. This is distinctly different from what occurs with AFB. In some instances the disease may also affect sealed larvae and, rarely, pupae. When this happens, the larva usually dies in a partially curled or distorted position, only rarely lying straight on the lower side of the cell as it does when infected with American foulbrood. Affected larvae are not always the same color, as with AFB, but may be yellow, gray, or brown, or a mixture of these colors. The air tubes, or tracheae, often remain visible in the larva infected with EFB. Their presence helps to distinguish the disease from AFB, in which no tracheae can be seen in the decaying brood. The odor of European foulbrood may be described as being sour or similar to the odor of

rotting fish. As with AFB, it is best not to use odor for diagnosis because of its variability and the differences in the ability of people to distinguish odors.

The typical consistency of EFB-infected larvae is dough-like. The remains may be somewhat ropy but less slimy and elastic than those of AFB-infected bees. When pulled out of the cell, the material reacts like dough or taffy when the pieces separate. Dried scales in comb may appear similar to those of American if lying straight in the cells. However, most of them are turned or twisted in the cell and can be easily removed, whereas the scales of AFB are difficult to remove. Worker, drone, and queen larvae are all susceptible to EFB.

European foulbrood may be controlled by use of Terramycin in the same way as American foulbrood. This dual control exerted by the antibiotic makes it a good choice for preventive feeding where both diseases are a threat. Honey bee strains vary in their resistance to European foulbrood. When only one or a few colonies are affected, they should be requeened with a different strain of bees and the disease will usually disappear. The organisms associated with European foulbrood are usually present even in hives that do not show symptoms of disease. The susceptibility of the particular strain of bees and, perhaps, nutritional factors bring about the appearance of the disease at damaging levels.

Sacbrood. Sacbrood disease is caused by a virus and is common but rarely serious in Illinois. Like European foulbrood, it must be distinguished from American foulbrood.

The presence of sacbrood-infected larvae produces a spotted appearance of the brood combs, a condition shared with all other brood diseases. The larvae die extended on the lower side of the sealed cells, and after they die part or all of the cappings may be removed by the adult bees. The skin of the dead larva does not rot as it does if the larva has died of foulbrood. Instead, it remains tough and encloses the watery contents like a sack, giving the disease its name. The head of the dead larva darkens more rapidly than the rest of the body and stays upright in the cell. It has been compared with the tip of a wooden Dutch shoe. The elevated head of the completely dried larva remains readily visible in the cell. Such a scale is easily removed from the cell.

Sacbrood is most common in the spring, usually affecting only a few cells in a comb. Occasionally a very susceptible queen may have large numbers of affected larvae. The disease usually requires no treatment. In severe cases, the colony should be requeened with a young queen from a different strain of bees.

Other brood diseases. There are several other diseases of bees that attack the brood. Most of them are not known in Illinois or are so rare that they need not be considered here. Included are parafoalbrood, stonebrood, and chalkbrood. Plant poisoning of brood does not occur in Illinois.

Chilled or starved brood may sometimes be confused with diseased brood. It is usually found outside the cluster area of small colonies and lacks most of the specific symptoms of the diseases because all brood stages may be affected. When the weather warms or the colony receives a new supply of food, the bees will quickly clean out all of the dead brood.

Adult Bee Diseases

Adult bees suffer from several diseases that are usually found in most colonies but rarely cause serious damage. In some other parts of the world, a mite, *Acarapis woodi*, causes acarine disease when it infects the tracheae, or breathing tubes, of the bee's thorax. This mite has not been found in the United States or Canada, and both countries prohibit the importation of adult bees to prevent the introduction of acarine disease. Several other species of external mites are found on honey bees in the United States and elsewhere but they do not cause any noticeable damage to the colonies.

Nosema disease. Nosema disease is an infection of the digestive organs of the adult bee by a single-celled organism, a protozoan called *Nosema apis*. Small numbers of infected bees may be found at almost any time of year in apiaries throughout the United States. The natural defenses of the individual and the colony against disease tend to keep it under control. However, when the bees are confined to the hives by poor spring weather, or subjected to stress from moving or special manipulations, such as those for queen rearing and for shaking package bees, the disease may reach damaging levels. The lives of infected bees are shortened, and affected colonies are weakened and sometimes killed.

Very rarely do nosema-infected colonies show any external symptoms. For this reason, positive diagnosis can be made only by examination of bees for the presence of spores of *Nosema apis*. To do this, ground-up abdomens or alimentary tracts must be examined under a microscope at 400 \times magnification to detect the organism.

The disease is cyclical in its severity in the colony, with a peak of infection in late spring and the low point in late summer or during the fall. It can be controlled, at least in part, by feeding the antibiotic fumagillin (Fumidil B). Complete control is difficult because of the

chronic nature of this infection in the bee's alimentary canal. The antibiotic must be available to the bees for a considerable time to rid them of the organism. The spores of the nosema organism are spread within and outside the colony with food and water. Infected bees soil the combs and spread infection within the colony. However, nosema infection does not cause dysentery, but bees suffering from dysentery may or may not have nosema disease. Combs contaminated with spores may be heated to 120° for 24 hours or fumigated with glacial acetic acid to kill the spores. Treatment is not necessary except where a serious disease problem exists. Control with fumagillin is most effective in the fall when the normal level of the disease is lowest. Treatment in the spring is less effective. Affected colonies can also be helped by giving them frames of brood and bees from other colonies.

Dysentery. Although it is not a disease, dysentery is considered here because so many beekeepers think of it as a disease symptom, especially of nosema disease. Bees with dysentery are unable to hold their waste products in their bodies and they release them in the hive or close to it. The condition is recognized by the dark spots and streaks on combs, on the exterior of the hive, and on the snow near the hive in late winter (Fig. 69). Dysentery is caused by an excessive amount of water



Dysentery of bees is indicated by the spotting of the hive and the snow around it in late winter. (Fig. 69)

in a bee's body. The consumption during the winter of coarsely granulated honey or honey with a high water content is one cause of the disease. Damp hive conditions may also contribute to the problem. Good food and proper wintering conditions are important to prevent the problem but there is no control for it once the bees are affected. Combs from colonies with dysentery can be used safely in other colonies.

Paralysis. Paralysis is a disease of the adult bee caused by a virus. Affected bees shake and twitch and are unable to fly. They usually die within a day or two. Other bees often pull at them and their bodies may be partially hairless and shiny. Little can be done to control the disease except to requeen the colony if it is seriously affected. However, the disease is rarely a problem.

Other diseases of adult bees. Adult bees also suffer from other diseases such as septicemia and amoeba disease. Both are extremely rare and of little importance in the United States.

Pests of Honey Bees

Wax moths. The greater wax moth (*Galleria mellonella*) is a serious pest of honey comb in Illinois and most areas of the United States. The adult moths are gray-brown and about $\frac{3}{4}$ inch long. In the daytime they are usually seen resting with their wings folded tent-like over their bodies (Fig. 70). When disturbed, the moths usually run rapidly



Adult greater wax moths in a typical resting position on comb foundation.

(Fig. 70)

before taking flight. They lay their eggs on unprotected honey combs and in the cracks between hive bodies of colonies of bees. The grayish-white larvae (Fig. 71) are kept under control by the bees in normal colonies and do no harm. They may completely ruin the combs in weak or dead colonies and in stored equipment. Unless they are controlled, they feed on the cocoons, cast skins, and pollen in the combs, and reduce them to a mass of webs and waste products (Fig. 72). Keeping strong colonies and fumigating stored equipment (see page 83) are the best ways to avoid damage from wax moth.

Several other less common moth larvae are sometimes found in combs. They usually feed only on the pollen in individual cells and are not a pest in Illinois. Fumigation for greater wax moth controls all such moths.

Mice. Mice are a pest of stored combs and unoccupied combs in bee hives, usually in the fall and winter. They chew the combs, eat pollen, and build nests among the combs. In the late fall, hive entrances should be reduced to $\frac{3}{8}$ inch in depth either by entrance cleats or by reversing the bottom board to the shallow side. Excluders or tight covers on stacks of stored combs will help to keep them mouse-free. Since mice may chew into the supers, storage areas should be protected with bait boxes containing an effective mouse poison. In apiaries where mice are a serious problem, poison bait may be placed beneath the hives or in bait boxes within an empty hive. Use all poisons with care, keep them out of reach of children, and follow the directions on the labels.

Skunks. Skunks feed on bees at night by scratching at the front of the hive and eating the bees as they come out to investigate the



Larvae of the greater wax moth, nearly full grown. (Fig. 71)



A stored comb ruined by feeding of wax moth larvae. Cocoons are visible among the webbing and on the frame top at the bottom of the illustration. (Fig. 72)

disturbance. People no longer trap skunks for their pelts, and the animals are increasing in numbers in many areas of Illinois. It is not unusual to find several in one apiary. The skunks weaken the colonies by eating large numbers of bees and are most damaging in the fall and winter after brood rearing has ceased. They also make the colonies mean and difficult to handle. If a colony suddenly stings more often and more bees fly around your veil, look for scratching in the soil at the front corners of the hives. Where skunks are numerous, they may dig enough to leave a trench in front of the hive. Their presence can also be detected by fecal pellets that are composed largely of honey bee remains. Control skunks by trapping or poisoning them.

Other pests of bees. Ants, toads, bears, birds, dragonflies, and other animals prey on bees. Ants can be controlled by treating their nests with insecticides such as chlordane or dieldrin. These materials are highly toxic to bees and should not be used close to the hives. Single colonies can be placed on stands or benches protected by oil or sticky barriers. The other pests are generally not a problem in Illinois. However, purple martins eat bees as well as other insects and may weaken colonies in areas where there are large numbers of nesting sites. Woodpeckers and flickers sometimes make holes in hives.

Human beings are often a serious pest of bees kept in outapiaries. They may tip the hives over with their cars or by hand, shoot holes in

them, or steal honey and leave the hive covers off. Apiaries should be visited regularly to watch for such damage. The problem may be lessened by posting your name and address in the apiary in a conspicuous place.

Pesticides and Honey Bees

Toxicity of pesticides. Many materials that are used to control insects, weeds, and plant diseases are toxic to honey bees. These pesticides are placed in three groups in relation to their effects on bees. *Highly toxic* materials are those that kill bees on contact during application and for one or more days after treatment. Bees should be moved from the area if highly toxic materials are used on plants the bees are visiting. Among the materials in this group are:

aldrin	Imidan
arsenicals	lindane
azinphosethyl (Ethyl Guthion)	malathion, dilute ^a
azinphosmethyl (Guthion)	malathion, low volume
Azodrin	Matacil
BHC	Metacide
Bidrin	methyl parathion
Bomyl	Methyl Trithion
carbaryl (Sevin)	mevinphos (Phosdrin) ^b
diazinon	Mobam
dichlorvos (DDVP, Vapona)	naled (Dibrom) ^b
dieldrin	parathion
dimethoate	phosphamidon
EPN	tepp ^b
famphur (Famophos)	Zectran
Gardona	Zinophos
heptachlor	

^a Kills bee primarily on contact.

^b Short residual activity. Can usually be applied safely when bees are not in flight. Do not apply over hives.

Moderately toxic materials can be used with limited damage to bees if they are not applied over bees in the field or at the hives. Correct dosage, timing, and method of application are essential. This group includes:

Abate	endrin
carbophenothion (Trithion)	methyl demeton (Meta Systox)
chlordane	oxydemetonmethyl
DDT	(Meta Systox R)
demeton (Systox)	Perthane
disulfoton (Di-Syston)	phorate
endosulfan (Thiodan)	tartar emetic

The greatest number of materials are included in the *relatively nontoxic* group. These pesticides can be used around bees with few precautions and a minimum of injury to bees. The following materials are included in this group:

allethrin	folpet (Phaltan)
Aramite	Genite 923
<i>Bacillus thuringiensis</i>	glyodin
binapacryl (Morocide)	maneb
Bordeaux mixture	methoxychlor
captan	Morestan
chlorbenside	nabam
chlorobenzilate	nicotine
chloropropylate	Omite
copper compounds	ovex
cryolite	Polyram
Dessin	pyrethrum
dicofol (Kelthane)	rotenone
Dimite (DMC)	sabadilla ^a
dinitrocyclohexylphenol	Strobane
(DNOCHP)	sulfur
dinocap (Karathane)	TDE (Rhothane)
dioxathion (Delnav)	tetradifon (Tedion)
dodine (Cyprex)	toxaphene
Dyrene	trichlorfon (Dylox)
ethion	zineb
fenson	ziram
ferbam (Fermate)	

^a Twenty-percent dust may cause bee losses.

Pesticides damage colonies in several ways. Most often they kill the field bees without other effects on the colony. In some instances the bees die in large numbers after returning to the hive. Many bees are also lost in the field and the colony is weakened but not usually killed. Sometimes materials are carried by the bees to the hive where they kill brood and young bees in the colony. The entire colony may die when this happens.

Methods of application. Losses from pesticides can be minimized by cooperation among beekeepers, farmers, and spray operators. Several basic principles should be followed to prevent losses of bees and to avoid injury to people and farm animals. The first of these is to apply the proper dosages and follow the recommendations on the label. The method of application is also a factor to consider. Ground application is generally safer than air application. The material and its formulation play important roles in its toxicity to bees. In general,

sprays are safer than dusts, and emulsifiable concentrates are less toxic than wettable powders. Materials applied as granules are the least hazardous. At present there are no safe, effective repellents that can be used to keep bees away from treated areas.

Proper timing of applications of pesticides allows the use of moderately toxic materials on crops visited by bees. Bees visit different crops at different times and for different periods during the day. The timing of treatment of a crop should relate to these bee visits. Squashes, pumpkins, and melons are attractive to bees early in the day but close their blossoms in the afternoon. Afternoon and evening treatments, after the flowers close, are safest for bees. Sweet corn sheds pollen early and is visited by bees most heavily in the morning. Applications of carbaryl for earworm control are least dangerous when made as late as possible in the day, especially if the insecticide is kept off the tassels. For most crops, pesticide applications are safest for bees if they are made between 7 p.m. and 7 a.m.

The beekeeper's obligation. Beekeepers have responsibilities in preventing losses to their bees and in learning to accept some damage, especially in providing pollination services. In some areas, honey bee losses must be anticipated and the risk weighed against the possible returns from honey or pollination fees. Beekeepers should be familiar with commonly used pesticides and their toxicity to bees. They should know as much as possible about the relations of their bees to the nectar and pollen plants in their territory.

It is essential that the owners of bees can be located easily when a nearby crop or the surrounding area is being treated with toxic materials. Therefore, a beekeeper should provide his name, address, and telephone number to owners of land on which his bees are located. This information should also be posted in the apiary in large, readable letters. Beekeepers' organizations should compile directories of apiary locations and their owners in each county, and make them available, together with marked maps, at the office of the county extension adviser.

Additional information is available in Circular 940, Pesticides and Honey Bees, available from your county extension adviser or from the Office of Publications, 123 Mumford Hall, Urbana, Illinois 61801.

POLLINATION BY HONEY BEES

Pollination is the transfer of pollen grains, the male sex cells of a flower, from the anther where they are produced to the receptive surface, or stigma, of the female organ of a flower. Since the honey bee is the most important insect that transfers pollen between flowers and between plants, the word "pollination" is often used to describe the service of providing bees to pollinate crop plants. This service is now more important than ever in Illinois because the acreage of insect-pollinated crops is large as compared with the number of all kinds of bees (honey bees, bumble bees, and solitary bees) that are available to provide pollination. In the 20 years from 1947 to 1967 the estimated number of colonies (hives) of bees in Illinois dropped from 232,000 to 93,000. Growers can no longer assume that there are sufficient numbers of bees nearby to produce the best possible crop from insect-pollinated plants.

Honey bees are good pollinators for many reasons. Their hairy bodies trap pollen and carry it between flowers. The bees require large quantities of nectar and pollen to rear their young, and they visit flowers regularly in large numbers to obtain these foods. In doing so, they concentrate on one species of plant at a time and serve as good pollinators for this reason. Their body size enables them to pollinate flowers of many different shapes and sizes. The pollination potential of the bees is increased because they can be managed to develop high populations. The number of colonies can also be increased as needed and the colonies can be moved to the most desirable location for pollination purposes.

Honey bees are most active at temperatures between 60° and 105°. Winds above 15 miles per hour reduce their activity and stop it completely at about 25 miles per hour. When conditions for flight are not ideal, honey bees work close to their colonies. Although they may fly as far as 5 miles in search of food, they usually go no farther than 1 to 1½ miles in good weather. In unfavorable weather, bees may visit only those plants nearest the hive. They also tend to work closer to the hive in areas where there are large numbers of attractive plants in bloom.

The following Illinois crops must be pollinated by bees to produce fruit or seed:

Apple	Muskmelon, cantaloupe
Apricot	Nectarine
Blackberry	Peach
Blueberry	Pear
Cherry	Persimmon, native
Clovers	Plum, prune
Sweetclovers, white and yellow	Pumpkin
True clovers	Raspberry
Alsike	Squash
Red	Trefoil
White Dutch, Ladino	Watermelon
Cucumber	

The following Illinois crops set fruit or seed without insect visits but yields and quality may be improved by honey bees:

Eggplant	Okra
Grape	Pepper
Lespedeza	Strawberry
Lima bean	

Honey bees visit several important Illinois crops but do not improve their yields of fruit or seed. These include:

Field bean	String or snap bean
Pea	Sweet corn
Soybean	

The provision of bees for pollination of crop plants is a specialized practice, not just a sideline of honey production. Beekeepers who supply bees for pollination must learn the skills of management that are necessary for success in this phase of beekeeping. Such skills include the development and selection of strong colonies that are able to provide the large force of field bees needed to do the job of transferring pollen. This task of the beekeeper is hardest to accomplish for fruit pollination early in the year. Each beekeeper or organization of beekeepers should set minimum standards for colony strength and size to use as a basis for establishing prices and for providing the best possible service. The number of bees, and not the number of hives, is the true unit of measure, and growers need to be told and shown what standards are being used to measure the honey bee colonies for pollination. For example, colonies for apple pollination should be housed in a two-story hive with a laying queen. There should be four or more frames with brood and sufficient bees to cover them. There should also

be a reserve food supply of 10 pounds of honey or more. Colonies rented to pollinate crops that bloom later in the year should be proportionately stronger, with 600 to 800 square inches of brood (five or six frames with brood). In the field, the colonies must be supered and examined at intervals to keep them in suitable condition for pollination.

The number of standard colonies per acre of crop plants varies in relation to the attractiveness of the crop, the competition from surrounding sources of nectar and pollen, and the percent of flowers that must produce fruit or seed to provide an economic return. Most Illinois crops are adequately pollinated by one strong hive of bees per acre. However, red clover grown for seed should have two or more colonies per acre moved to the field as soon as it begins to bloom (Fig. 73). Hybrid cucumbers grown at plant populations of 40,000 to 70,000 or more plants per acre for machine harvest may require up to four hives per acre. The higher number of hives may be needed where other cultivated plants or weeds compete strongly for the attention of the bees.

Bees for pollination should be placed within or beside the crop to be pollinated. For apples, place groups of five to 15 hives at intervals of 200 to 300 yards (Fig. 74). They should be moved in at 10 to 25 percent bloom. For cucumbers and other cucurbits, bees should be moved to the field when the first female flowers appear, not before. Place the bees in a single group for small fields. For fields larger than 30 acres, place the bees in two or more groups at the edges of the field but leave no more than $\frac{1}{10}$ mile between groups.



Pollination of second crop red clover for seed. Honey bees are effective pollinators of red clover in July and August when other clovers have ceased to bloom. Illinois produces about one-sixth of the red clover seed in the United States. (Fig. 73)



Honey bee hives placed in groups in an apple orchard in southern Illinois. (Fig. 74)

Bees need a nearby source of water such as a farm pond or a stock tank with cork floats on which they can land. Water is important in the early spring for brood rearing and later for cooling the hives. In fruit pollination the bees benefit from full sun and shelter from the wind. Later in the year, some afternoon shade is helpful.

Contracts for honey bee pollination services should be a regular part of the business when more than a few hives are involved. Contracts prevent problems that may arise from misunderstanding, and they serve to emphasize the obligations and rights of both grower and beekeeper. Contracts should include provisions relating to pesticide usage, colony standards and the rights of the grower to examine the colonies, rights of access by the beekeeper, pollination fees and time of payment, and a statement about the timing of movements of bees to and from the crop.

Colony rental fees vary in relation to the expenses involved and the length of time the colonies are needed. The potential or actual honey production of the rented colonies is also a factor in establishing prices for summer-blooming crops. Prices of \$5 to \$15 per colony are reasonable for properly managed bees. Additional moves and the movement of colonies by growers are usually valued at a minimum of \$2 per colony.

GLOSSARY

Abdomen — the last major body region of the bee, one of three regions.

Acarine disease — a disease of adult bees caused by mites (*Acarapis woodi*) infesting the tracheae. Not known to be present in North America.

Acid board — a metal covered wooden frame used with carbolic acid to drive bees from honey combs.

Adrenalin — a drug used for treatment of severe reactions to bee stings; also called epinephrine.

Alimentary canal or tract — the passage in the bee's body that food goes through from mouth to anus.

American foulbrood (AFB) — an infectious disease of immature honey bees caused by a bacterium, *Bacillus larvac*.

Apiary — a place where bees are kept.

Apiculture — beekeeping.

Balling — the clustering of bees tightly around a queen bee, usually in an attempt to kill her.

Bee blower — a portable machine that produces large volumes of rapidly moving air to blow bees from combs.

Bee brush — a soft bristled brush used for removing bees from combs.

Bee escape — a metal tube through which bees can move in only one direction.

Bee space — a $\frac{1}{4}$ - to $\frac{3}{8}$ -inch space through which a bee can move freely; the space between the frames and exterior parts of a hive. Bees will not build comb in it or seal it with propolis, thereby allowing the frames to be removed easily.

Bee veil — a wire screen or cloth enclosure worn over the head and neck to protect them from bee stings.

Beeswax — a substance secreted from glands on the bee's abdomen that is used to construct comb.

- Benzaldehyde** — a liquid used to drive bees from honey combs; a component of oil of bitter almond. It has a smell that is pleasant to humans.
- Boardman feeder** — see entrance feeder.
- Bottom board** — the floor of a hive.
- Brood** — the immature stages of the bee (egg, larva, and pupa) considered together.
- Brood chamber** — the part of the hive in which young bees are reared. It usually includes one or two hive bodies with combs.
- Brood nest** — the area within the combs in which young bees are reared. It may include only part of one comb or many combs.
- Burr comb** — small pieces of comb built between combs and parts of the hive.
- Butyric anhydride** — a liquid used to drive bees from honey combs. It has an odor unpleasant for humans similar to that found in rancid butter and perspiration.
- Carbolic acid** — a liquid used to drive bees from honey combs; also called phenol.
- Carniolan bee** — a dark honey bee race originating in southeastern Europe.
- Castes** — the different kinds of adult bees in a colony; workers, drones, queens.
- Caucasian bee** — a dark honey bee race originating in the Caucasus.
- Cell** — a single compartment in a honey comb.
- Chunk honey** — a piece or pieces of comb honey packed in a jar with liquid extracted honey.
- Cleansing flight** — bee flight, after a period of confinement, to dispose of feces or body wastes.
- Colony** — an entire honey bee family or social unit living together in a hive or other shelter.
- Comb** — a beeswax structure composed of two layers of horizontal cells sharing their bases, usually within a wooden frame in a hive. The words "comb" and "frame" are often used interchangeably; for example, a frame of brood, a comb of brood.
- Comb foundation** — a sheet of beeswax embossed on each side with the cell pattern.
- Comb honey** — honey in the sealed comb in which it was produced; also called section comb honey when produced in thin wooden frames called sections.

- Creamed honey** — finely granulated honey produced by adding fine honey crystals to liquid honey.
- Cucurbit** — a plant in the family Cucurbitaceae, which includes squash, pumpkin, watermelon, muskmelon, and cucumber.
- Cut comb honey** — a portion of comb honey cut from a larger comb.
- Division-board feeder** — a waterproof wooden syrup container the size of a frame, used to feed bees within the hive.
- Division screen** — a wooden frame with two layers of wire screen that serves to separate two colonies within the same hive, one above the other.
- Draw** — to shape and build, as to draw comb.
- Drawn comb** — a comb constructed on a sheet of foundation.
- Drifting** — the return of field bees to colonies other than their own.
- Drone layer, drone-laying queen** — a queen that is unable to lay fertilized eggs because of failure to mate or lack of sufficient spermatozoa; a queen whose eggs produce drones in worker cells.
- Dysentery** — a malady of adult bees marked by an accumulation of excess feces or waste products, and by their release in and near the hive.
- Entrance feeder** — a wooden runway that fits into the hive entrance so that bees may obtain syrup from an inverted jar.
- Enzyme** — an organic substance produced in plant or animal cells that causes changes in other substances by catalytic action.
- Epinephrine** — see adrenalin.
- Ethylene dibromide** — a liquid used to fumigate honey combs for control of wax moth.
- European foulbrood (EFB)** — an infectious disease of immature honey bees caused by a bacterium, *Streptococcus pluton*.
- Excluder** — a thin grid of wire, wood and wire, or sheet zinc, with spaces wide enough for workers to pass through but not queens or drones. It is used between hive bodies to confine queens to one part of a hive.
- Extracted honey** — liquid honey removed from the comb by means of an extractor.
- Extractor (honey extractor)** — a hand- or power-driven device that removes honey from the comb by centrifugal force.
- Field bee (forager)** — worker bee that collects nectar, pollen, water, and propolis at locations outside the hive.

Foulbrood — a general name for infectious diseases of immature bees that cause them to die and their remains to smell bad. The term most often refers to American foulbrood.

Foundation — see comb foundation.

Frame — a wooden rectangle that surrounds the comb and hangs within the hive. It may be referred to as Hoffman, Langstroth, or self-spacing because of differences in size and widened end bars that provide a bee space between the combs. The words "frame" and "comb" are often used interchangeably; for example, a comb of brood, a frame of brood.

Fume board — a general name for any shallow wooden cover used to hold repellents for driving bees from honey combs.

Fumigant — a material that acts as a disinfectant or pesticide in a gaseous form when exposed to air.

Genetic or hereditary makeup — the characteristics of an individual inherited from its parents.

Granulated honey — honey in which crystals of a sugar (dextrose) have formed.

Granulation — the formation of sugar (dextrose) crystals in honey.

Hive — a wooden box or other container in which a honey bee colony lives.

Hive body — a single wooden rim or shell that holds a set of frames. When used for the brood nest, it is called a brood chamber; when used above the brood nest for honey storage, it is called a super. It may be of various widths and heights and adapted for comb honey sections.

Hive cover — the roof or lid of a hive.

Hive loader — a mechanically operated boom and cradle for manipulating hives and placing them on a truck.

Hive tool — a metal bar used to loosen frames and to separate the parts of a hive.

Honey — a sweet, viscid fluid produced by honey bees from nectar collected from flowers.

Honeydew — a sweet liquid, primarily plant sap, excreted by plant-feeding insects and often collected by honey bees.

Honey flow — see nectar flow.

House bee — a young worker bee, 1 day to 2 weeks old, that works only in the hive.

- Hybrid bees** — the offspring resulting from crosses of two or more selected inbred lines (strains) of bees; the offspring of crosses between races of bees.
- Inbreeding** — breeding by continual mating of related individuals.
- Inner cover** — a thin wooden hive lid used beneath a telescoping cover.
- Italian bee** — a yellow honey bee race originating in Italy.
- Langstroth hive** — a hive with movable frames made possible by the bee space around them. It was invented by L. L. Langstroth.
- Larva, larvae** — the grub- or worm-like immature form of an insect; the second stage in metamorphosis.
- Laying worker** — a worker bee that produces eggs that normally develop into drones.
- Legume** — the common name for plants of the pea family, Leguminosae, including clover, sweetclover, vetch, alfalfa, and many other nectar and pollen plants.
- Metamorphosis** — the series of changes through which an insect passes from the egg to larva, pupa, and adult.
- Nectar** — a sweet liquid secreted by plant glands (nectaries) usually located in flowers, but also found on other parts of plants.
- Nectar flow** — the period when abundant nectar is available for bees to produce honey for storage in the combs of the hive.
- Nosema disease** — an infectious disease of adult bees caused by a protozoan, *Nosema apis*.
- Nuc** — abbreviation for nucleus.
- Nuc box** — a small hive used for housing a small colony or nucleus.
- Nucleus, nuclei** — a small colony of bees usually with enough workers to cover two to five frames or combs.
- Nurse bee** — a young bee, usually 2 to 10 days old, that feeds and cares for immature bees.
- Outapiary** — an apiary located some distance from the beekeeper's home.
- Ovary** — the egg-producing part of the female reproductive system.
- Package bees** — two to 4 pounds of worker bees, usually with a queen, in a screen-sided wooden cage with a can of sugar syrup for food.
- Pallet** — a cleated wooden stand on which supers are stacked for bulk handling; also used to hold two to seven hives for moving, especially for pollination service.

Paradichlorobenzene (PDB) — a white crystalline substance used to fumigate combs and to repel wax moths.

Paralysis — a disease of adult bees caused by a virus.

Pentachlorophenol (penta) — a liquid wood preservative used for hive parts.

Pesticide — a general name for materials used to kill undesirable insects, plants, rodents, and other pests.

Pfund color grader — an instrument used to classify the color of samples of liquid honey.

pH — a symbol for a measure of relative acidity or alkalinity of solutions; values below 7 are acid, values above 7 are alkaline.

Phenol — see carbolic acid.

Pistil — the female part of a flower that includes the ovary, style, and stigma.

Play flight — short flight in front of the hive taken by young bees when they first leave the hive; an orientation flight.

Pollen — male sex cells, usually very small and powdery, produced in the anthers of a flower.

Pollen basket — an area on a bee's hind leg where pollen is packed and carried with help from a central spine and surrounding hairs.

Pollen insert — a device placed in the hive entrance to apply live pollen to outgoing bees.

Pollen substitute — a mixture of materials such as soy flour, casein, brewers' yeast, and dried milk fed to bees to stimulate brood rearing.

Pollen supplement — a mixture of pollen substitute and pollen fed to bees to stimulate brood rearing.

Pollen trap — a device that removes pollen pellets from bees' legs as they enter the hive.

Pollination — the transfer of pollen from the anther to the stigma, the receptive surface of the female organ of a flower; in beekeeping terms, pollination often refers to the service of providing bees for pollination of crop plants.

Pollinator — an agent, such as an insect, that transfers pollen.

Pollinizer — a plant that furnishes pollen to another plant.

Propionic anhydride — a liquid used to drive bees from honey combs.

Propolis — plant resins collected from plants by bees to use in sealing cracks and crevices in hives; bee glue.

- Pupa, pupae** — the inactive third stage in the complete metamorphosis of an insect. The adult body form is evident at this stage.
- Queen-cage candy** — a firm mixture of powdered sugar and liquid invert sugar used in queen cages as food for the queen and her attendant bees.
- Queen excluder** — see excluder.
- Queenless colony** — a honey bee colony without a queen.
- Queenright colony** — a honey bee colony with a queen.
- Rabbit** — a piece of wood or metal on which the frame ends hang in the hive.
- Refractometer** — an instrument for measuring the percent of soluble solids in a solution designed to read directly in percent moisture; used for measuring the percent moisture in honey and nectar.
- Reproductive system** — the organs of the body, either male or female, concerned with producing offspring.
- Requeening** — removal of a queen from a colony and introduction of a new one.
- Robber bee** — a field bee from one colony that takes, or tries to take, honey from another colony.
- Robbing** — the stealing of honey from a colony by bees from another colony.
- Royal jelly** — a mixture of glandular secretions of worker bees fed to developing queens.
- Sacbrood** — a virus disease of immature honey bees.
- Scout bee** — a field bee that locates new sources of food, water, or propolis, or a new home for a swarm.
- Sealed brood** — immature bees in their late larval and pupal stages within capped cells of the comb.
- Section comb honey** — honey in sealed comb produced in thin wooden frames called sections.
- Sex alleles** — hereditary characteristics of bees that, in part, determine the sex of the individual bee.
- Slumgum** — the refuse from melted combs after all or part of the wax is removed.
- Smoker** — a steel container with an attached bellows in which burning materials furnish smoke to repel and subdue honey bees.
- Social bees** — bees that live in groups or colonies, such as bumble bees, stingless bees, and honey bees.

Solar wax extractor (solar melter) — a glass-covered box used for melting combs and cappings by heat from the sun.

Solitary bees — bees that live alone and survive the winter, usually in an immature stage in a cell in the ground or a variety of other sites.

Spiracles — the openings to an insect's internal breathing tubes, the tracheae.

Stigma — the receptive surface of the female organ of a flower that receives the pollen.

Super — a hive body used for honey storage above the brood chambers of a hive.

Supering — placing supers of comb or foundation on a hive, either to give more room for brood rearing or for honey storage.

Supersedure — replacement by the bees of an established queen with a new one without swarming.

Swarm — a group of worker bees and a queen (usually the old one) that leave the hive to establish a new colony; a word formerly used to describe a hive or colony of bees.

Thorax — the middle body region of an insect to which the wings and legs are attached.

Trachea, tracheae — the breathing tube of an insect.

Transferring — moving bees and comb from a natural nest in a cavity or container to a movable frame hive.

Uncapping — cutting a thin layer from a comb surface to remove the wax covering from sealed cells of honey.

Uncapping knife — a knife, usually heated, for cutting cappings from honey comb.

Uniting — combining one honey bee colony with another.

Unsealed brood — eggs and larvae in open cells.

Virgin queen — an unmated queen.

Wax moth — an insect whose larvae feed on and destroy honey bee combs.

Wired foundation — comb foundation manufactured with vertical wires embedded in it for added strength.

Wiring — installing tinned wire in frames as support for combs.

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Magazines and Journals

- American Bee Journal. Hamilton, Illinois 62341.
- Bee World. Hill House, Chalfont St. Peter, Gerrards Cross, Bucks., England.
- Gleanings in Bee Culture. Medina, Ohio 44256.
- Journal of Apicultural Research. Hill House, Chalfont St. Peter, Gerrards Cross, Bucks., England.

Beekeeping Organizations

- Write to the Extension Apiculturist, 107B Horticulture Field Laboratory, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801, for the current addresses and names of officers of the following organizations:
- American Beekeeping Federation
 - American Honey Institute
 - Illinois State Beekeepers' Association
 - Local Illinois beekeeping associations

Beekeeping Supplies and Equipment

- Dadant & Sons, Inc. Hamilton, Illinois 62341.
- Chr. Graze K. G. 7057 Endersbach bei Stuttgart, Germany.
- Hubbard Apiaries. Onsted, Michigan 49265.
- Walter T. Kelley Co. Clarkson, Kentucky 42726.
- Leahy Manufacturing Co. Higginsville, Missouri 64037.
- August Lotz Co. Boyd, Wisconsin 54726.
- A. I. Root Co. Medina, Ohio 44256.
- A. G. Woodman Co. Box 1692, Grand Rapids, Michigan 49501.
- Package bees and queens:* consult current issues of beekeeping magazines for sources.

State of Illinois

- Apiary inspection and state laws relating to bee diseases and movement of colonies: Apiary Division, Illinois Department of Agriculture, Springfield, Illinois 62705.
- Beekeeping and pollination information: Extension Apiculturist, 107B Horticulture Field Laboratory, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

State regulations on production and marketing of honey: Division of Foods and Dairies, Department of Public Health, 130 North Franklin Street, Suite 800, Chicago, Illinois 60606.

U.S. Department of Agriculture

Beekeeping publications and information: Apiculture Research Branch, Entomology Research Division, Plant Industry Station, U.S. Department of Agriculture, Beltsville, Maryland 20705.

Disease diagnosis: Bee Pathology Laboratory, Entomology Building A, Agricultural Research Center, U.S. Department of Agriculture, Beltsville, Maryland 20705.

Monthly honey market news, and grades for extracted and comb honeys: Fruit and Vegetable Division, Consumer and Marketing Service, Washington, D.C. 20250.

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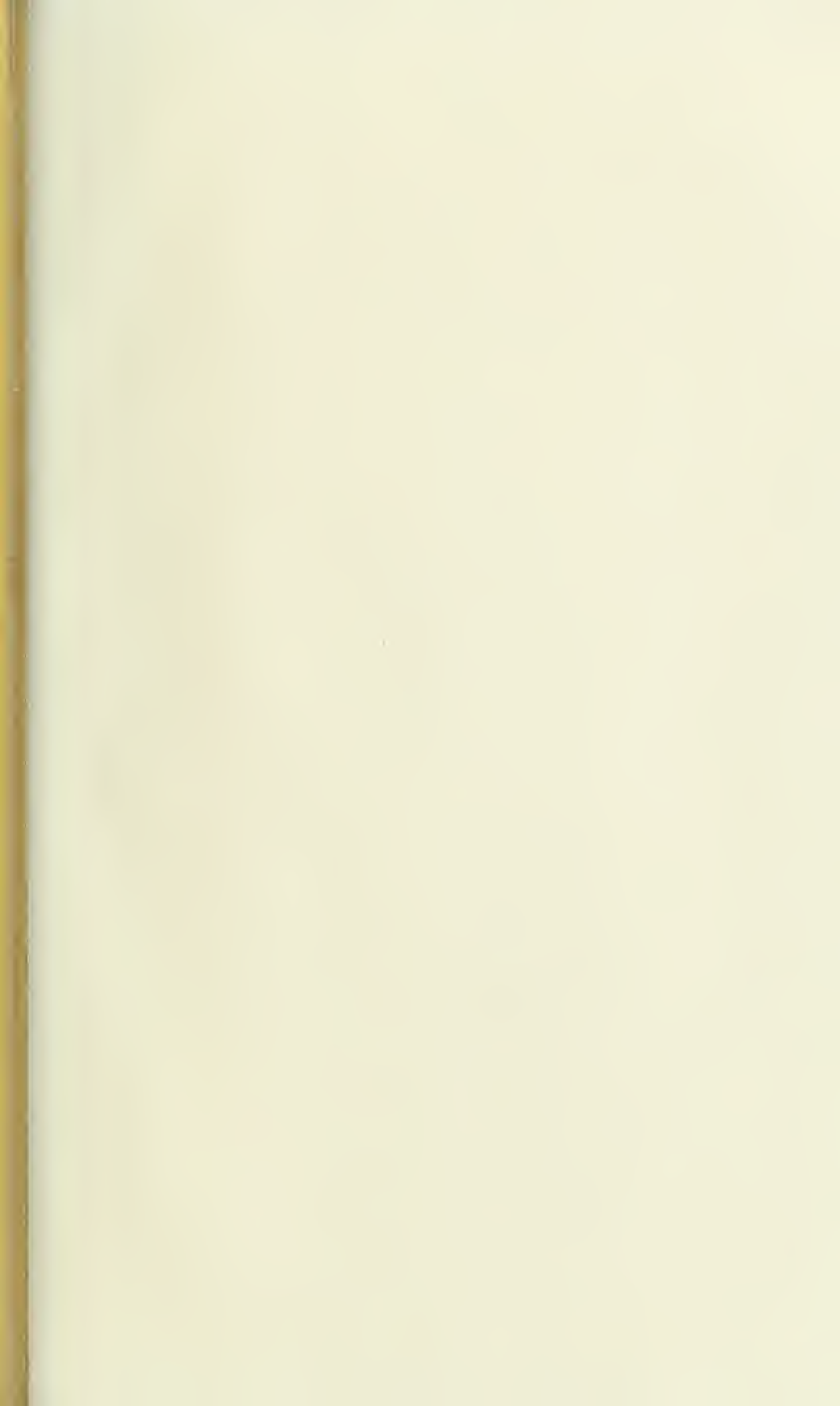
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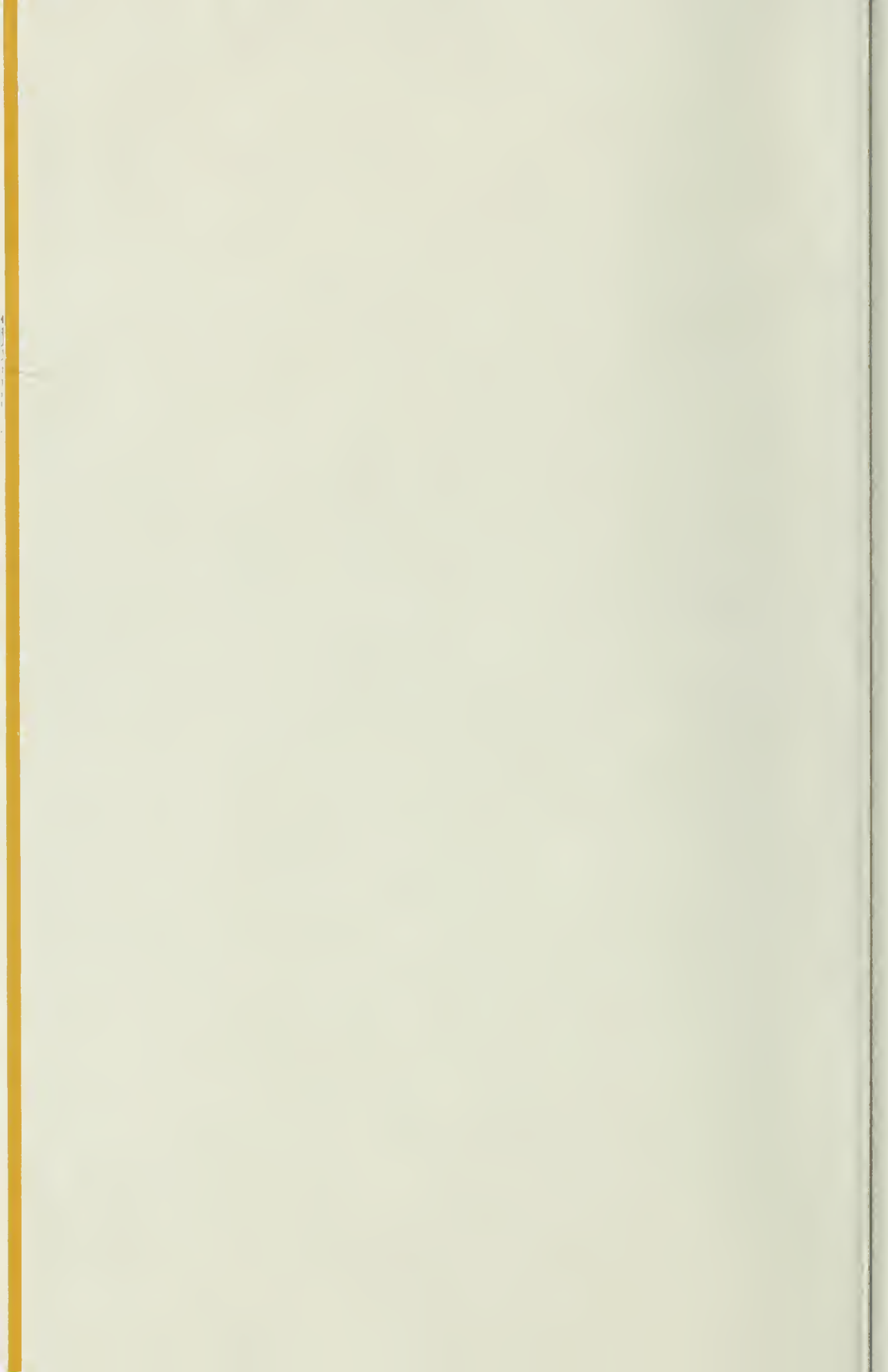
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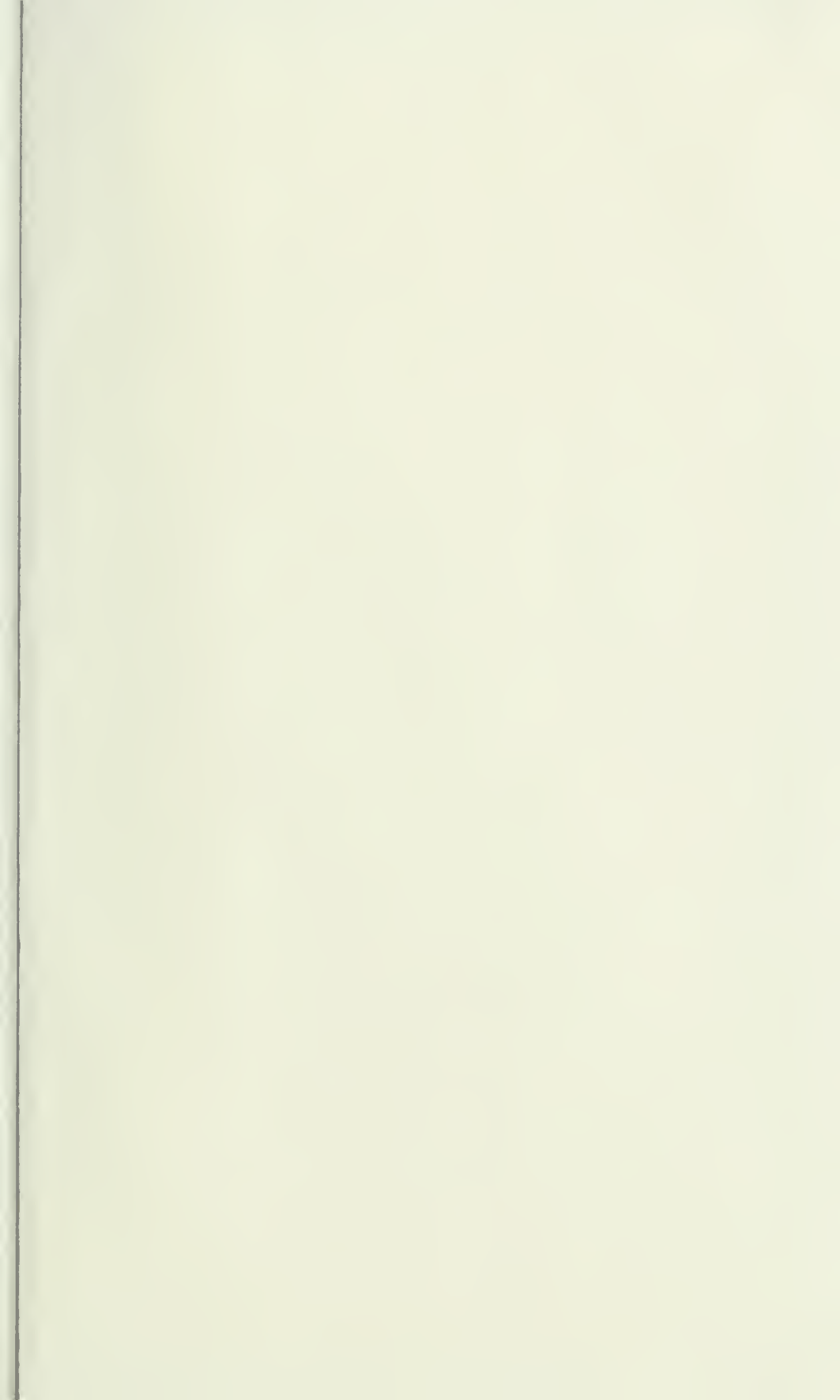
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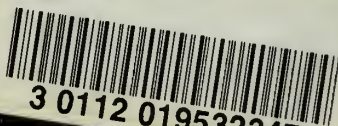








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